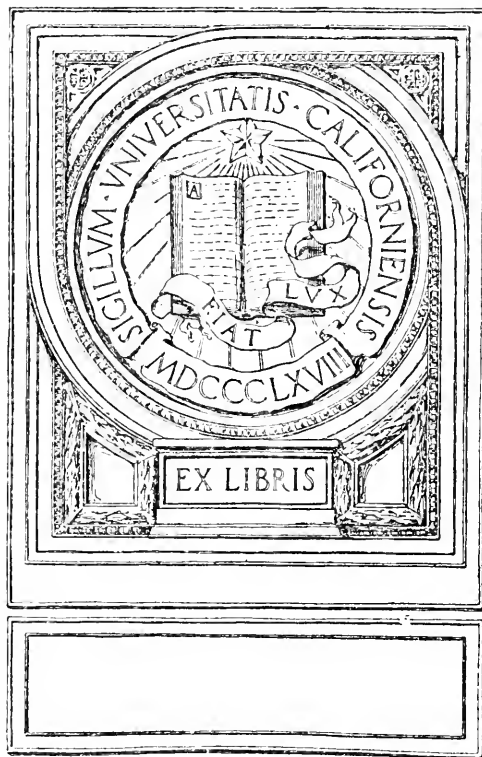




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THE HANDWRITING MOVEMENT

THE HANDWRITING MOVEMENT

A STUDY OF THE
MOTOR FACTORS OF EXCELLENCE IN PENMANSHIP

AN INVESTIGATION CARRIED ON WITH THE AID OF A
SUBSIDY BY THE GENERAL EDUCATION BOARD

By

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PREFACE

Don. Summer 1922

This report is designed for two types of readers—the technically trained student of the science of education and the practical administrator. The scientific student is interested in the details of the methods and results of experimentation by which the validity of the practical conclusions may be judged. He takes a critical attitude toward the methods of the experimentation and the interpretation of the results. The practical administrator, on the other hand, is interested primarily in the conclusions of experimentation and in the rules of practice which are to be derived from them. The report has been organized in such a way that the demands of both these types of readers may be met. For the sake of the technically trained student full details of the method and results have been included. For the sake of the reader who is interested primarily in the practical outcome the methods and results of the experiments are summarized and printed in bold-faced type. By reading the summaries of Chapters I to V inclusive and then selecting from the detailed discussion in Chapters III and IV concrete examples of the general principles which appear in the summaries, it is possible to gain a general conception of the character of the laboratory experiment and of the nature of the handwriting movement as revealed by it. The more directly practical part of the report is contained in Chapters VI and VII. These chapters give an outline of the method of teaching writing which was derived from the laboratory study and present the results of the practical trial of this method under ordinary school conditions. It is possible to carry over directly into the school the practices which are here described. A more detailed statement of these practices in the form of a handwriting manual is in preparation.

F. N. F.

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The experimental investigation which is reported in this monograph was begun in the spring of 1915 by taking some motion pictures of handwriting. The following year, 1915-16, the General Education Board made an appropriation which made it possible greatly to enlarge the equipment used in the study and to secure the services of Mr. C. F. Dunn, who devoted his entire time to the work of taking photographs and measuring the records. A continuation of the grant during the year 1916-17 made possible a similar arrangement with Mr. P. V. West.

While the intensive study by means of the motion-picture camera was being made in the laboratory, Mr. H. W. Nutt, who commenced to make some measurements of the writing movement of children, was enabled to extend the range of his study.

At the end of the first year of experimentation Miss Mary L. Dougherty conducted a small training class in order to work out a course of teaching to put in practice the principles discovered in the laboratory. During the next year she further elaborated this course and supervised its trial in the Longfellow School, Kansas City, Kansas.

To all those who assisted in the experiment and to the General Education Board, which made the work possible, the author is deeply indebted.

The following school superintendents and principals contributed to this study by affording the opportunity to experiment upon the pupils of their schools: Superintendents W. A. Greeson, of Grand Rapids, Michigan; H. B. Wilson, of Topeka, Kansas; J. W. Gowans, of Winfield, Kansas; V. F. Wiley, of Mattoon, Illinois; Supervisor E. H. Jackson, of Kansas City, Kansas; and Principal Arthur O. Rape, Ray School, Chicago, Illinois. Superintendent M. E. Pearson, of Kansas City, Kansas, permitted three schools to co-operate in the pedagogical experiment. Miss Minnie M. Martin, principal of the Bryant School, and Miss Gertrude

Highleyman, principal of the Quindaro School, each conducted four tests during the course of a year in order that their schools might be used as check schools. Miss Grace Roberts, principal of the Longfellow School, and her teachers made a painstaking trial of an experimental course in writing during a period of eight months. The teachers of the Elementary School of the University of Chicago and Principal H. O. Gillet co-operated in the investigation by making possible the organization of a special class of poor writers and by facilitating the experimentation with the children in the laboratory. To all these, and especially to Miss Roberts and her staff, the author is heartily grateful.

CHAPTER I

INTRODUCTION AND SURVEY OF PREVIOUS STUDIES

GENERAL SUMMARY

The study which is the subject of this report had two aims, a theoretical one and a practical one. The theoretical aim was to analyze the writing activity of good and poor writers and to discover the difference between them. The practical aim was to find and test means of training the poor writer so that his mode of writing would resemble that of the good writer. The theoretical aim was subordinate to this practical aim.

The theoretical aim was pursued by means of two analytical experiments. The one was an intensive detailed study in the laboratory of the writing movement of 50 children and 15 adults. The second was a less detailed study of the writing movement of 273 public-school children. Previous laboratory investigations of writing had furnished the ground for a description of the more important features of the writing movement in general and had thrown some light on its development. They had not, however, attempted to differentiate between the activity of the good and the poor writer.

Three phases of the writing activity were examined in the present study. The first was the position of the hand and arm, including the grasp of the penholder. Five aspects of hand position were studied. The good and poor writers were classified under each of these aspects, and statistics were compiled in order to determine what types of position are more common among good than among poor writers. Finally practical rules for guidance in teaching hand position were derived.

The second phase that was studied was the writing movement in its gross aspect, which is usually designated by the terms "finger movement," "hand movement," and "arm movement." The varieties of movement were classified under four heads. The purpose was to compare the various writers in what may be called the composition of the movement. The movement as a whole may be composed of varying proportions of finger movement, hand movement, wrist movement, and arm movement. Some varieties are more common among good writers and others are more common among poor writers.

The third phase is perhaps the most important. It concerns the manner in which the movement of the pen varies in rapidity from one part of a letter or word to another. The speed of movement of the pen is never uniform. It fluctuates between slow and rapid flights, which are broken at frequent intervals by actual pauses. The flights of the pen, which are separated from one another by pauses or by marked retardation in speed, may be described as units of movement. Good and poor writers differ in the manner in which they divide the whole movement into units. On the basis of these differences, methods of training the child in organizing the movement into units were devised.

The completion of the experiment from the practical point of view consisted in testing the teaching methods and devices which were derived from the analytical study. This was done first with a small group of poor writers who had been studied in the laboratory. These pupils were taught in a room adjoining the laboratory in order that the details of procedure might be gradually perfected by observing the children write. They were again studied in the laboratory at the end of the training period and the changes in their writing activity were recorded. They made sufficient improvement during two or three months to warrant a more extended trial of the methods by which they had been taught.

A more extensive trial of the methods which were worked out with the trial class was undertaken by introducing them into an entire public school for a period of eight months. A manual was written and mimeographed and put into the hands of the teachers. The results of eight months' teaching were carefully measured by means of tests and compared with the progress made by two other schools in the same city. The training school made much greater progress during the year than the two schools with which it was compared, and it exceeded greatly the average yearly progress in writing.

SCHOOL SURVEYS AND THE BEARING OF THEIR RESULTS ON THE PROBLEM OF WRITING

Widespread tests¹ of the writing ability of school children indicate that we should expect continuous progress in both form and speed throughout the elementary-school period. There is no

¹ C. H. Judd, *Measuring the Work of the Public Schools*. Cleveland Education Survey, Russell Sage Foundation. F. N. Freeman, *Fourteenth and Sixteenth Yearbooks of the National Society for the Study of Education* (Chicago: University of Chicago Press); *School Survey of Grand Rapids, Michigan* (1916), pp. 129-46; *Survey of St. Louis Public Schools* (1917), pp. 213-58.

marked periodicity in development which is common to the various school systems in which tests have been made. So far as the development of the child's inherent ability is the determining factor, both form and speed improve at a fairly constant rate.

When we examine an individual school or even a school system, on the other hand, we find deviations from this rule. These deviations most commonly consist in differences in the relative advancement in the two characteristics of form and speed. In one school, for example, the form will be found to improve most rapidly in the lower grades and the speed in the upper grades, while in another school the relation is reversed.


Besides these differences in the periodicity of advancement, there are marked variations among different school systems in their degree of attainment in writing. In one large school system which was investigated the eighth-grade children did not write as well as the sixth-grade children in another system. Still more marked differences may be found between different schools in the same city.

These marked variations in the ability of children in different cities or schools indicate that some teachers are more successful than others in the methods which they pursue. They indicate further that it is possible to discover what the more efficient methods are and to apply them to the improvement of the teaching of writing. It would be possible to investigate the difference between efficient and inefficient methods by making a minute study of those methods pursued in places where writing is taught well and comparing them with the methods where it is taught poorly. This method of investigation, however, would merely enable us to judge between the systems of teaching which are already in existence.

A method of investigation which is more fundamental in character, because it is based primarily upon the activity of writing instead of existing methods of teaching, is a study of the variations in the writing habit itself. All the surveys of writing, as of the other school subjects, have revealed a tremendous variation in the ability of different children of the same age and grade. The fundamental cause of these individual differences is undoubtedly to be found in differences in natural ability. Individual

differences may be reduced very considerably in amount, however, as is indicated by the fact that they are greater in some school systems than they are in others.


An example of the influence which teaching exerts upon individual differences is to be found in the relationship between speed and form in writing. If we test all the pupils of a grade in both these characteristics we find that many types of relationship exist. There are some pupils who write rapidly and form their letters well. There are others who write slowly and well. There are pupils who write rapidly and poorly and those who write slowly and poorly, and the list might be extended to include all the possible combinations. If now we compare the number of pupils in these various possible groups we find that in some school systems there are more pupils who write rapidly and poorly than there are who write rapidly and well; and there are more who write slowly and well than slowly and poorly. In other words, there is an opposition between the characteristics of speed and form, and the higher degree of either of these two qualities is attained at some sacrifice of the other. In other school systems, on the contrary, this opposition does not appear. Those pupils who, as a group, write rapidly have as high a score in form as those who write slowly. Evidently not only the degree of attainment but also the type of attainment at which the pupil shall aim, or which he shall reach, is amenable to the influence of teaching. We are justified, therefore, in setting up standards which shall determine both the attainment we should expect of the child in his writing achievement as a whole and also the relation which should be kept between achievement in the two elements of form and speed. These variations make very insistent the problems of efficiency in writing and the best means of attaining it.



THE RESULTS OF PREVIOUS STUDIES OF THE WRITING ACTIVITY

SUMMARY

Previous laboratory studies have shown that the writing movement is a complex and delicate co-ordination. The thumb and the first two fingers exert continually varying degrees of pressure upon the penholder as the different strokes of the letters are produced. The movement of



the fingers and of the hand and arm are combined in a complex manner. Some of these component elements of the movement are more prominent in some individuals, and others are more prominent in other individuals, but each element has its characteristic part to play. The formation of the letter is attended by a series of fine pressure changes of the pen upon the paper. As the writer acquires skill he comes to make particular letter forms with the characteristic pressure changes. The speed of movement of the pen is also continually changing, and these changes of speed are intimately adapted to the forms of the letters which are being written. A straight stroke increases in speed toward the middle and usually decreases toward the end. When the direction of the stroke is changed the speed is reduced. Long strokes are made with greater speed than short strokes, with the result that strokes widely differing in length may be made in the same or nearly the same length of time. This is a manifestation of the disposition to rhythm which is characteristic of so many activities. The speed of a writing stroke is also affected by the complexity of the stroke itself and by the complexity of the strokes which follow it. Pen movements can be made more rapidly in some directions than in others. The direction of most rapid movement is from lower left to upper right and the opposite, and the direction of slowest movement is from upper left to lower right and the opposite. The conditions of writing should be so arranged that the movement from the lower left to the upper right is utilized. As a child grows older his writing becomes more rhythmical, the succeeding strokes follow one another more closely, and there is marked increase in the rapidity and accuracy of the writing movement.

There are three general aspects of the writing movement which we may consider. The two which ordinarily come to mind, and to which the teacher of writing gives chief attention, are the composition of the movement and the position of the hand and arm. Composition is illustrated by the distinction between the finger movement and arm movement, and hand position is illustrated by the distinction between a level wrist and a tilted wrist. The experimental study of the positions or types of composition of the movement which are in actual use gives ground for conclusions regarding the types which should be taught.

That the fingers co-operate in an intricate and delicate manner has been shown by recording the pressure which is exerted upon

the penholder by the thumb and the first and second fingers.¹ When a straight downward stroke is made, the forefinger exerts the chief pressure, the thumb and second finger guiding. When the stroke curves to the left, the middle finger exerts greater pressure than the thumb. The difference between the production of a loop and a straight return stroke lies in a little extra pressure by the thumb or the second finger. Evidently the part which the fingers play in letter formation is an important one, unless the finger movements are eliminated by drill, which the present study shows to be very infrequent.

That the part which the fingers play in writing cannot be disregarded is shown by another study² and by further evidence in the present investigation. The share which the fingers have in driving the pen is recorded by means of an instrument, called the hand tracer, which is attached to the outer side of the hand, and which records by means of a pen or pencil the movements of the hand in writing. By comparing this record with the writing itself it is possible to determine how much is done by the hand and how much by the fingers. No case was reported in which all the work of forming the letters was performed by the hand and arm. In some cases the part played by the fingers was less than in others, but in no case was it negligible. The present investigation has studied the relation of the finger and arm movements further by compiling statistics of the relation of arm movement (1) to the pupil's age, (2) to the type of training he has received, and (3) to the excellence of his writing.

The effect of the hand or arm position on writing has been the subject of but one scientific experiment. This study dealt with the effect of the pronation of the hand on the slant of the writing. As the hand moves toward the right side of the page the pen slants more and more toward the right, causing an increase in the slant of the letters unless the tendency is counteracted in some way. A group of adults were set the task of making the slant of their

¹ G. Obici, "Ricerche sulla Fisiologia della Scrittura," *Rivista sperimentale di frenitica e medicina legale della alienazioni mentale*, XXIII (1897), 623 and 870.



² C. H. Judd, *Genetic Psychology for Teachers*. New York: D. Appleton & Co.

writing uniform across the page, and it was found upon examining the methods they adopted to secure this end that a number of them had formed the habit of gradually turning the hand palm down (pronation). So far as the writer is aware, this method has never been taught to pupils in the schools. It is commonly assumed that there is one position of the hand, or slope of the wrist, which is the best, and that this is to be kept uniform. Other, rather clumsy, devices are sometimes used to keep the slant of the writing uniform. The commonest, so far as the writer's observation goes, is to teach the pupil to shift the position of the paper toward the left at intervals while the line is being written. The conclusions from the experiment on pronation accord with the view that some adjustment in hand position is desirable in order that the hand may adapt itself to varying demands and conditions. With this conclusion the result of the present study will be found to agree. Beyond this an attempt will be made to evaluate various hand and arm positions by comparing the positions assumed by good and poor writers.

The composition of the writing movement, and the hand and arm position, affect the manner in which the pen point is actuated. We may, in the third place, analyze the characteristics of the pen movement itself without regard to its method of production. The two aspects of the movement of the pen which have been studied are the changes in the pressure which it exerts upon the paper and in its speed. Studies of the pressure changes in writing bear upon the present study only indirectly, but their general outcome may be summarized. The method of experimentation on pressure is to have the subject write upon a balance which is sensitive enough to record the ordinary variations in pressure. The hand is supported upon a solid table and only the pen bears upon the balance.¹ Two contrasted points of view concerning the changes in the writing movement which accompany the development of the habit have arisen from the studies of pressure, and apply also to changes in

¹ A. Diehl, "Ueber die Eigenschaften der Schrift bei Gesunden," *Psychologische Arbeiten*, III (1901), 1-61; F. N. Freeman, *Preliminary Experiments in Writing Reactions*, Psychological Monograph, VIII (1907), No. 29, 301-33; A. Goldscheider, "Zur Physiologie und Pathologie der Handschrift," *Arch. f. Psychiatrie*, XXIV (1892), 503-25.

speed. The first is held by several German investigators,¹ who describe the writing of the beginner as consisting of a succession of independent strokes, each made by a separate nervous impulse. This conception arose from the observation that the pressure of the writing of beginners indicated a pronounced pressure impulse corresponding to each downstroke. In the case of the practiced writer the pressure was found to be continuous from stroke to stroke, to rise to maximum toward the middle of a series of strokes, and to gradually fall from this culminating point toward the end. The writing of the adult was described as proceeding from a total impulse rather than from a series of single impulses.

An American study² reports a different situation. The pressure exerted by children was found to be as continuous as that exerted by adults, and there was nowhere found a clearly marked, pronounced series of impulses on the downstrokes, separated by almost entire release of pressure. The explanation of this difference may lie in the form and construction of the letters in the German and English script (compare the  and ).

More productive than the study of pressure changes has been the measurement of changes in speed from one part to another of the writing stroke. The writing stroke does not proceed at a uniform rate of speed, and the variations in speed can be detected and correlated with certain facts, the form of the letters being among the most important.

Five different methods of measuring writing speed in detail have been used, but only the two which were employed in this investigation will be described in this report. Descriptions of the other methods are to be found in the reports referred to in the footnote.³

¹ E. Meumann, *Vorlesungen zur Einföhrung in die Experimentelle Pädagogik*, Vol. III, Chap. XVIII.

² F. N. Freeman, *An Experimental Study of Handwriting*, Psychological Monograph, 1914, No. 75.

³ A. Binet and Courtier, "Sur la vitesse des mouvements graphiques," *Rev. Phil.*, XXXV (1893), 664-71; F. N. Freeman, *Preliminary Experiments in Writing Reactions*, Psychological Monograph, VIII, No. 20; W. R. Jack, "The Analysis of Voluntary Muscular Movements by Certain New Instruments," *Journal of Anatomy and Physiology*, XXIX (1895), 473-79; C. N. McAllister, *Researches on Movements Used in Writing*, Studies from Yale Psychological Laboratory, VIII (1900), 21-63.

Previous to the beginning of the present study the general nature of the speed changes in writing had been discovered. Consider, to begin with, a form of writing which is simpler than the production of letters, in order to gain a clear idea of the fundamental principles that govern the speed changes in writing. If one makes a single straight line or stroke with the pen it will be found by measuring the

speed of the pen point throughout the course of the stroke that it is not uniform. The stroke gradually gathers speed at the beginning and gradually loses speed at the end, until it comes to a full stop. If an instrument is arranged so that a strip of paper moves underneath the sheet on which the writing is done, with a typewriter ribbon between the two in order to take a tracing of the movement, the manner in which the pen movement accelerates and retards may be displayed graphically and measured. In

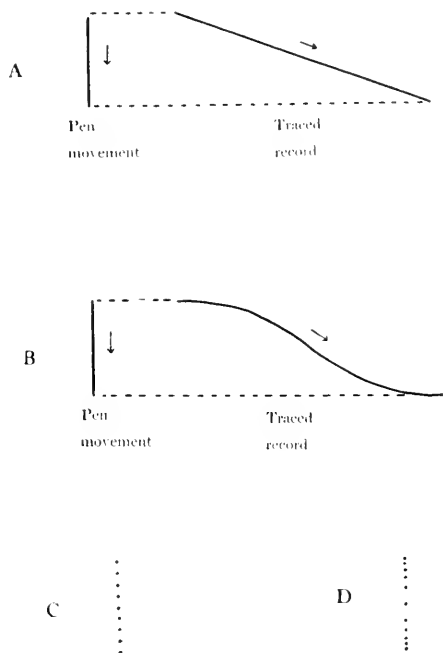


FIG. 1.—Illustrations of graphic methods of recording the speed of writing strokes.

making a straight vertical line, if the speed of the movement were uniform throughout the stroke, the traced record would show a straight oblique line, as shown in Fig. 1A. But what we actually get is a curved line which slopes more sharply at the middle than at the ends, as shown in Fig. 1B.

The same characteristic may also be shown by another method. We may write with an instrument which does not trace a continuous line but which makes a succession of punctures in the paper by means of a needle driven forward at the rate of 1,000 strokes a

minute. Or we may use a pen which is connected with an induction coil so that it throws off electric sparks in rapid succession. If we write with such a pen on smoked paper, the sparks make a series of dots on the paper. With either of these devices the speed of the writing stroke is indicated by the distance between the points on the paper. If the speed were uniform the dots would be an equal distance apart throughout the stroke, as shown in Fig. 1C; but instead we find the dots crowded together at each end and spread out in the middle, as shown in Fig. 1D.

This characteristic of the writing movement might have been predicted from the general principle of inertia, that the application of a constant force to a mass originally at rest produces an accelerated motion, and that the application of a constant force in opposition to a mass in motion produces a gradually retarded motion. The hand or fingers and the pen are the masses to be moved and the muscular contraction constitutes the force.

If we make a series of strokes instead of a single stroke we find the same acceleration at the beginning and retardation at the end of the strokes, but modified by the fact that in most cases the pen does not completely stop at the end of each stroke. Certain investigators have stated the law thus: The amount of retardation in speed at a point where a stroke changes its direction, or where a new stroke begins, is proportional to the amount of angular change in direction. This law holds roughly, and would hold completely if the writing stroke were governed solely by mechanical principles; but there are other conditions also which govern the speed changes in writing.

Perhaps the most important of these additional principles is the principle of rhythm. Writing is not alone in its subjection to rhythm. The involuntary bodily activities, such as breathing, the beating of the heart, alternation of sleep and wakefulness, are regular in their recurrence. It has long been known that work can be performed with less fatigue and greater precision when it is done rhythmically. It has been discovered also that the practiced writer exhibits a considerable degree of rhythm in his writing. For example, if we compare the speed with which the different letters of the alphabet are written with the length of the line which

the pen traces in making them, we shall find a close correspondence between the two. The letters having the longest lines are generally made with the most speed, those having shortest lines with the least. As a consequence the longer letters are made in nearly the same length of time as the shorter ones.

Some investigation of the development of rhythm in the writing of the child was made previous to the study here reported in some detail. In general, rhythm, in the sense of an approach to equality in the time taken to write successive strokes, increases markedly as the child grows older and acquires greater skill. Rhythm in this sense, then, is a mark of maturity and practice. By means of drill the pupil's writing may be made more rhythmic, and if the rate which is chosen is not beyond the pupil's capacity and stage of development his writing becomes better co-ordinated, with no deterioration of form as a result.¹

It has been held² that another mark of distinction between the writing of the child and the adult is a more marked separation between the strokes of the child's than of the adult's writing. The child is said to write a word with a series of separate nervous impulses or innervations and the adult with a total nervous impulse or innervation. This opinion was derived from a study of the pressure records from individuals who wrote German script. In an earlier study³ the writer did not find a greater continuity in adult than in children's writing. The former study dealt with only a small number of individuals, and its conclusion is contradicted by the present study. So far as the speed changes are concerned it may be taken as established that the child's writing movement is divided more markedly into a series of separate or distinct movements than is the writing of the older person. The interpretation of this fact we shall discuss below.

There is another aspect of the mature person's writing of connected words which can be interpreted as due to the withdrawal of

¹ M. K. Smith, "Rhythmus und Arbeit," *Philosophische Studien*, XVI (1903), 71; D. Awramoff, "Arbeit und Rhythmus," *Psychologische Arbeiten*, XVIII (1903), 515-62.

² E. Meumann, *Vorlesungen zur Einführung in die Experimentelle Pädagogik*, Vol. III, Chap. XVIII.

³ F. N. Freeman, *An Experimental Study of Handwriting*, Psychological Monograph, 1914, No. 75.

the attention from the minute portion of the stroke being made at the moment. When letters are connected in a word, or even when strokes are connected in a letter, the speed of the stroke is affected not only by the form or length of the stroke itself but also by the character of the preceding and following strokes. A simple experiment in drawing lines brings out this interdependence of successive strokes. If we ask a person to draw lines at a given signal, each time starting as rapidly as possible, we find that the length of time which is required to start is affected by the number of conditions we place upon the movement. If the length of the first line is not determined and its direction is determined only by a guiding straightedge, if the second line is required to be drawn to a given point, and the third line to be the beginning of a diamond-shaped figure, the starting-time of the three lines will be very different. It will take decidedly longer to begin the line to be drawn to a given point and the line which is the beginning of a diamond than it will to begin the line which is made with less restriction.

A similar influence of subsequent strokes on a preceding one may be illustrated by a comparison of the three letters *a*, *d*, and *g*. The first stroke of each of these letters in script is identical with the others in form and length, and yet they are made with different speed. The first stroke of *a* is the slowest, the corresponding stroke of the *d* is made more rapidly, and the first stroke of the *g* is made more rapidly still. The stroke in each case is but the part of a letter, and the writer has the whole letter in mind when he writes each stroke. Since, according to the general principle laid down in another paragraph, there is a disposition to make the various letters in the same length of time, each part of the letter is modified as may be necessary to bring this about. The attention of the mature writer is more inclusive in its scope than that of the child, and this causes modifications in the details of the strokes. As we shall see in the later description of the results of this experiment, this modification in the speed of the strokes also produces a modification in the form of the letters.

It may be seen from this brief account of the results of previous studies of the speed changes within letters and words that we

have here a characteristic which is a very important element of the writing activity, and which throws unexpected light on the causes of the form of letters and even on the mental processes which accompany the writing act. The further investigation of these speed changes is one of the chief problems in the present investigation.

Three other studies of the speed of hand movements have some bearing on writing, and their results may be briefly described.¹ The aim of these studies was to discover the direction in which hand movements similar to those used in writing can be made most easily. The general conclusion of these studies is that a movement from the lower left-hand corner to the upper right-hand corner of the desk, forming an angle of about 30° with the front edge of the desk, is the direction of the most rapid and easiest movement. This is the direction in which the sideward movement of the hand or forearm carries the pen when the arm is in the usual writing position and corresponds to the direction of the base line when the paper is tilted the usual amount to the left, 30° . It was proposed by Woodworth to use this movement in making the up and down strokes of the letters by tilting the paper about 60° to the right, but this necessitates an awkward movement of drawing the arm backward continually in passing from letter to letter.

One way of utilizing this free side sweep of the arm and hand seems to be to place the arm perpendicular to the base line of the writing so that the hand may move freely along the line. The present study shows this position to be advantageous. This requires the paper to be tilted, and indirectly requires the writing to be slanted. If it did not slant, the up and down strokes would take a direction from the upper left-hand to the lower right-hand corner of the desk, which was found to be the most difficult of all.

Certain experimental facts concerning the improvement of children's ability in making movements in general, and particularly writing movements, have a bearing on the organization of a course

¹ C. N. McAllister, *Researches on Movements Used in Writing*, Studies from the Yale Psychological Laboratory, VIII (1900), 21-63; D. P. McMillan, *Report of Child-Study Department and Pedagogical Investigation*, Chicago, 1902-3; R. S. Woodworth, *The Accuracy of Voluntary Movement*, Psychological Review Monograph Supplement, III (1899), No. 13.

in penmanship. Such an organization has been undertaken as a part of the present study for the purpose of testing these conclusions experimentally. The results of the studies¹ of all phases of motor ability are uniform in their general indication of a marked growth in ability as the child grows older. This is true of the ability to hold the hand steady, to make accurate movements, and to respond quickly to a signal. Every indication points to the necessity of making small demands on the young child in respect to both the accuracy and the speed of the writing movement.

¹ W. L. Bryan, "On the Development of Motor Ability," *American Journal of Psychology*, V (1892), 125-204; F. N. Freeman, "Current Methods of Teaching Handwriting," *Elementary School Teacher*, XIII (1912), 32; J. A. Gilbert, *Researches on the Mental and Physical Development of School Children*, Yale Psychological Studies, II (1894), 64; J. A. Hancock, "A Preliminary Study of Motor Ability," *Ped. Sem.*, III (1894), 9. 29.

CHAPTER II

THE METHODS AND APPARATUS OF THE MOTION-PICTURE STUDY

SUMMARY OF THE ENTIRE ANALYTICAL EXPERIMENT DESCRIBED IN DETAIL IN CHAPTERS II TO V¹

Motion-picture photographs make possible the accurate study of the hand and arm positions in writing, of the grosser movements of the hand, and of the finer changes in speed. Records can be made from the photographs by projecting them upon the screen and drawing the outline of the hand from the projected image. By comparing the drawings of the hands which are made at set places in the writing, the hand movements which take place between the positions represented in the drawings can be indicated.

The speed of movement of the pen can be measured by recording the distance which the pen point travels during each exposure of the camera or from one exposure to the next, and a speed curve can be constructed by plotting these successive distances on a chart. In the more extensive field study mechanical devices were used which made it possible to measure the relative amount of arm and finger movement and to record the speed changes of writing.

In the intensive study by the motion-picture method a comparison of the hand position and movement of the following groups was made: First, the three poorest and the one best writer of each grade in the University Elementary School, from the second to the seventh, inclusive; second, the four poorest and the four best writers of the fourth and the eighth grades of a public school; and, third, seven good and eight poor adult writers. The results of these comparisons are first presented by describing in detail a number of illustrative cases. The entire results are then presented in the form of tables, and the conclusions are drawn from these complete data.

The study of hand position deals first with the degree to which the hand is held with the palm facing downward, or the degree to which it is turned over toward the right so that the wrist is inclined. The public-school writers who had been trained in holding their wrists level and

¹ Summaries of parts of the discussion are also given on pp. 64, 71, and 94 of Chap. III; pp. 105 and 116 of Chap. IV; and p. 125 of Chap. V.

the children who had been given the experimental training course in connection with this experiment held their wrists more nearly level than did the other children. Good writers can be trained to hold their wrists level somewhat more easily than can poor ones. This feature of position is of particular significance in connection with the manner in which the hand is supported. It is characteristic of good writers to support their hands upon the third and fourth fingers, while poor writers more frequently allow their hands to rest upon the side. The third element of position is the angle of the arm with the line of writing. The forearm should be held nearly at right angles to the base line of the letters. These three items of position are organically related to one another in that they have a bearing upon the movement of the hand across the page. When the hand is kept sufficiently level so that the fingers can slide easily upon the paper, and when the forearm is nearly at right angles to the line of writing, the movement across the page can be made easily and fluently. The development of this movement was particularly emphasized in the organization of the training course. The third and fourth elements of position, which consist in the angle of the penholder with the strokes of the writing and its angle with the arm, do not appear to be particularly important. Two others, however—the relation of the fingers to the thumb in the grasp of the penholder and, in general, the looseness of grasp on the penholder—are of much significance. The forefinger should be placed on the penholder nearer the pen point than the thumb. When the forefinger is drawn up so as to be opposite the thumb, or above it, the writing is nearly always poor. The penholder should be grasped loosely in order to avoid cramping of the hand.

The various aspects of movement were studied in the same manner as those of position. The movement by which the hand is carried along the line was considered separately from the movement by which the letters are formed, and the sideward movement within words was distinguished from the sideward movement between words. The hand may be carried along the line from letter to letter or from word to word in a variety of ways. The entire forearm may be pivoted at the elbow or at the muscle pad in the forearm, and may revolve about one of these points as a center. In a similar manner the hand may revolve about the wrist joint. These are the two movements which prove to be the most efficient. Other movements which are less advantageous are the drawing in of the fingers or an adjustment within the hand itself, turning the hand over toward the right or the left and lifting the arm

and shifting its position. The sideward movement of the forearm and of the wrist is the one which can be carried out most easily while the letters are being produced. The other movements are more apt to be made intermittently. Lifting the arm and shifting its position quite obviously interrupts the formation of the letters. The sideward movements at the elbow and at the wrist also have the advantage that they do not get the hand into a cramped position.

The movements by which the letters are produced may be classified into those of the whole arm, of the hand as a whole, of the wrist joint, and of the fingers. None of the classes of writers who were examined wrote without finger movement and all classes used about the same percentage; that is, good writers used as much finger movement as poor writers, and those who had been trained in the use of the arm movement particularly used as much finger movement as did the pupils who had not been so trained. The writers who had been trained in the use of the arm movement used somewhat less hand movement and therefore more arm movement than did those who had not been so trained. The child cannot acquire the arm movement, even though it is made a direct object of drill, until he has acquired a certain amount of maturity and skill. A moderate degree of arm movement, however, will follow from the type of drill which was given in the present study. This drill did not have as its direct purpose the development of arm movement and nothing was said about the movement of the arm in the course. The exercises which had for their purpose the development of freedom and fluency of movement, however, resulted in the acquirement of a certain degree of movement of the arm. Contrary to the prevailing opinion, a close relation was not found to exist between the degree of arm movement and either the speed or the form of the writing. Such degree of arm movement as is profitable may readily be developed as a by-product of the type of training which has for its purpose the development of fluent and easy sideward movement of the hand across the page and does not require the great emphasis which is put upon it by modern systems of penmanship.

The analysis of the speed changes in writing indicates that they are an important factor in skill. Every writer pauses or retards the speed of his stroke at intervals during the word. In the good writer these pauses occupy a larger percentage of the writing time than in the poor writer. In other words, the good writer divides the total movement into units to a greater extent than does the poor one. This distinction is clearly brought out by accurate measurement and statistical

comparison. The successive units of the movement are not more uniform in duration in the poor writer than in the good writer, contrary to what might be expected. This gross type of rhythm does increase, however, as a child grows older. To get at the further distinction between the good and poor writer a more minute examination of the speed curves is necessary. Such examination shows that there is a very intimate connection between the changes of speed and the form of the letters which are to be produced. If the changes in speed are not appropriate, therefore, the form will be modified from the standard in a corresponding manner. The good writer, furthermore, makes the successive strokes in a consistent manner; that is, the strokes which are similar in form are made with similar changes in speed. A very abrupt stroke does not alternate with a stroke which increases in speed gradually, as is apt to be the case with the poor writer.

ASPECTS OF WRITING WHICH MOTION PICTURES REVEAL

The advantage of the motion-picture method of studying handwriting is, in brief, that it gives the most complete record of any method thus far devised, with the least inconvenience and distraction to the writer. The most significant aspects of the writing activity are the position of the arm, hand, and fingers in relation to the writing, the changes in position of these parts as the writing proceeds, and the variations in the speed of the writing stroke, including rhythm. The only element left out is the pressure exerted by the fingers or by the pen. The author, in his previous investigation, found this the least significant feature of the writing movement and therefore did not complicate the apparatus by including a study of pressure in this investigation.

The position of the hand, arm, and fingers can be represented and recorded with accuracy by motion pictures. The motion picture consists in a series of photographs taken in rapid succession on a long film. Each of these photographs represents the position of the hand at a particular stage of the movement. After the photograph has been made, any of these individual photographs can be projected on a screen and retained there for study for an indefinite length of time. We are thus able, so to speak, to catch a movement on the wing, and to hold it for study. A position of the hand which occupied about one-fortieth of a second can be studied

for an hour. Not only can the photograph be studied, but a diagram can be traced from it, and, if desired, measurements can be made. The changes in position from certain crucial points to other crucial points can be examined. For example, the change in position from the top to the bottom of a letter, or from the beginning to the end of a word, indicating the type of movement by which the intervening strokes were made, may be diagramed. One convenient and graphic method of displaying such changes in position is to trace the two positions of the hand on the same figure.

An added advantage of the motion-picture method for this study is that the positions and changes in position are shown in their relation to the writing itself, since each photograph includes a picture of all the writing up to the time it was taken, as well as the hand and pen.

This means of recording position enables us to study with accuracy the variations in such matters as grasp of the pen, degree of levelness of the wrist, manner in which the hand is supported, and the angle of the arm to the base line of writing. These features, again, are to be observed in relation to the record of the writing itself. As a consequence we can examine the effect of different methods of teaching on pen holding and hand position and can study what effect different positions have upon the excellence of the writing.

Speed changes are studied equally well by this method. The successive photographs are taken at equal intervals, the regularity of movement of the camera being checked by a device to be described below. The speed of the movement of the pen is therefore represented by the distance through which it travels between the exposures of the camera. The position of the pen at each exposure can be easily represented upon an enlarged tracing of the writing, and diagrams can be made from this to represent graphically the speed changes. The speed changes, as well as the hand positions, are represented directly in connection with the writing itself.

The advantage of the photographic method from the point of view of naturalness of conditions and absence of distraction is that the subject writes on an ordinary desk, with no machinery except a quiet clock on the desk or in the writer's immediate view, and

with nothing attached to his hand or any part of his body. The only possible sources of distraction are the artificial illumination, which is not annoying, the moving camera, which is four feet or more above the table and out of the subject's range of vision, its supporting framework, and the general atmosphere of an experiment. The observation of the experimenters is that the subjects were not seriously distracted, and that the conditions of the experiment were unusually free from sources of distraction.

APPARATUS AND TECHNIQUE

In order to secure stability and uniformity at high speed, it was necessary to use a good camera, a lens giving a sharply defined image with sufficient speed, and a convenient and accurate focusing device. The selection of a camera was rendered somewhat difficult by the stoppage of importation on account of the war, but a used camera in good condition of one of the better makes, the Urban, was finally found. With this camera (Fig. 2, 1) satisfactory photographs at a rate of over thirty exposures per second have been taken in the course of the experiment. Most of the photographs have been taken at twenty-five exposures per second, since this proved to be sufficiently rapid in most cases. The rate at which motion pictures are usually taken is sixteen per second. The more rapid rate was necessary in order to get a record of the details of the movement.

For most of the photographs the camera was driven by an electric motor (Fig. 2, 2). The shaft of the motor was coupled directly to the slow-speed shaft of the camera, which is geared so as to produce one exposure per revolution. The speed of the motor was regulated by a rheostat and had sufficient range to give any speed required. A speed indicator on the camera enabled the operator to set the rheostat so as to procure approximately the speed desired.

For a more exact determination of the speed of the camera and as a check on the uniformity of its motion, it was necessary to devise an additional means of measuring the rapidity of the exposures. A timer of the sort used by photographers in controlling the duration of exposures in printing was set in the table on which



FIG. 2.—General view of the photographic apparatus and arrangement: 1, camera; 2, motor; 3, reflector of lamp.

the subject wrote with the dial flush with the surface. This clock was included in all the photographs. It was regulated before being used. By means of this timer it was possible to count the number of exposures during successive second or half-second intervals. After the camera had gotten under way its speed was found to be remarkably constant. The number of exposures per second frequently did not vary throughout the course of a photograph, except at the initial acceleration and final retardation, and rarely varied more than one exposure during a record. This gives the records a limit of error of 4 per cent. Since the measurement of the records is relatively less precise than this and none of the conclusions depend on as high a degree of accuracy, the performance of the camera is thus indicated to be entirely satisfactory.

It would not have been possible, without a much more elaborate mechanism, to keep the rate of exposure exactly uniform from one record to another. One of the obstacles which would have been difficult to overcome was the variation in the electric current which drove the motor. But such uniformity was fortunately not necessary. The primary object of the experiment was not to compare the speed of the writing of different individuals, but rather to study the changes in speed within the writing of each individual and to compare these changes among different individuals. For this purpose all that was necessary was uniformity of speed within each record, and this was secured. If it was desired to find the average speed of writing of any individual, it could be done by observing the distance which the hand on the timer had moved during the writing of any specified letters or words.

The lens was a Zeiss-Tessar, F 3.5, 3-inch focal distance. This covered an area of 12×16 inches at a distance of 4 feet, the size of the film used in each exposure being $1 \times \frac{3}{4}$ inch. It was found unnecessary to use the full-sized aperture, and in the later photographs a somewhat better definition was secured by stopping down to about F 8.

The camera was focused by means of a tube which passed directly through it and exposed the image to view on a piece of developed film which was placed on the spot where the exposure was to be made.

The camera with its driving mechanism was placed vertically above the hand of the subject. The general arrangement of the apparatus is shown in Fig. 2. The chief reason for the choice of this position was that it gives photographs in which the writing, the hand, and all the objects included in the view are shown in their true relative proportions. This made it possible to compare the length of lines, distances on the writing or on the hand, by direct measurement. Furthermore, this position made it possible to get a better focus over the whole field. In the case of all but one writer it gave an unrestricted view of the writing. It gave a view of the hand from which it was possible to determine fairly well the position of its parts and the nature of its movement.

In the later photographs the view of the hand was made more complete by the use of two mirrors silvered on the front surface. One mirror was placed at an angle of about 45° to the table, directly in front of the hand and parallel to the base line of the writing. The other was placed in a similar manner to the left of the hand and parallel to the left edge of the paper. The use of these mirrors made it necessary to enlarge the field by raising the camera to a position 4 feet $8\frac{1}{2}$ inches above the table. The front mirror gave a good view of the hand in respect to its pronation or the opposite, and the side mirror gave a good view of the backward and forward movements of the fingers and of the manner of supporting the hand.

The ordinary commercial motion-picture film was used in making the negative; the negative was taken to a commercial firm to be developed, and this film was used in the study. A positive film would have given a much more realistic picture, but would have been no better as a basis for the drawings and the measurements, and would have added considerably to the expense.

After some consideration of the relative advantages of artificial illumination and daylight, artificial illumination was chosen for several reasons. First, artificial light is more constant and dependable. Secondly, the employment of daylight would necessitate working out of doors, and this would subject the experiment to the vicissitudes of the weather and confine it to the warmer seasons. Thirdly, it was necessary to mount the camera on a stable frame, and this necessitated a relatively permanent location. Artificial

illumination necessitated some additional expense, but it was justified by these reasons.

Three forms of artificial illumination were considered: nitrogen lamps, Cooper-Hewitt mercury lamps, and flaming arc lamps. The nitrogen lamps were excluded because of their excessive heat and their uncomfortable and injurious glare. The mercury lamps are very expensive and fragile. The flaming arc "studio" lamps (Fig. 2, 3) were found to be much more satisfactory than the nitrogen lamps and much less expensive than the mercury lamps. They furnish 9,000 to 10,000 candle-power each, give a relatively mild violet-colored light which is not unpleasant, and are not excessively hot. On warm days the temperature was kept comfortable by an electric fan. Two of these lights were used, one illuminating each side of the hand. The light was concentrated by means of reflectors directed downward at an angle of 45° .

After the photographs were taken it was necessary to project them upon a screen for study. In a preliminary experiment this was done by means of an ordinary stereopticon lantern. But this method, while it served for the separate study of the individual exposures, did not make it possible to get the motion-picture effect which was found to be desirable in the first inspection of the records. Accordingly one of the cheaper projection machines, the Optigraph, was bought, and a cooling bath and an attachment to facilitate the study of one exposure at a time were added. The projection set-up is shown in Fig. 3.

The attachment for studying a single exposure (Fig. 3, 3) was constructed in the following manner. The driving shaft, which is operated by gears driven by a handle, carries on the left side of the machine a small flywheel. One revolution of this flywheel exposes one section of the film. To this flywheel was bolted a ratchet wheel and a chain and weight (Fig. 3, 4), so adjusted that when the chain was pulled forward by the string (2) the shaft revolved. When the chain was released the weight pulled the ratchet wheel back to its original position without turning the driving shaft. The experimenter could thus remain at the screen at some distance from the projection machine and advance the film one section or more at a time at his convenience.

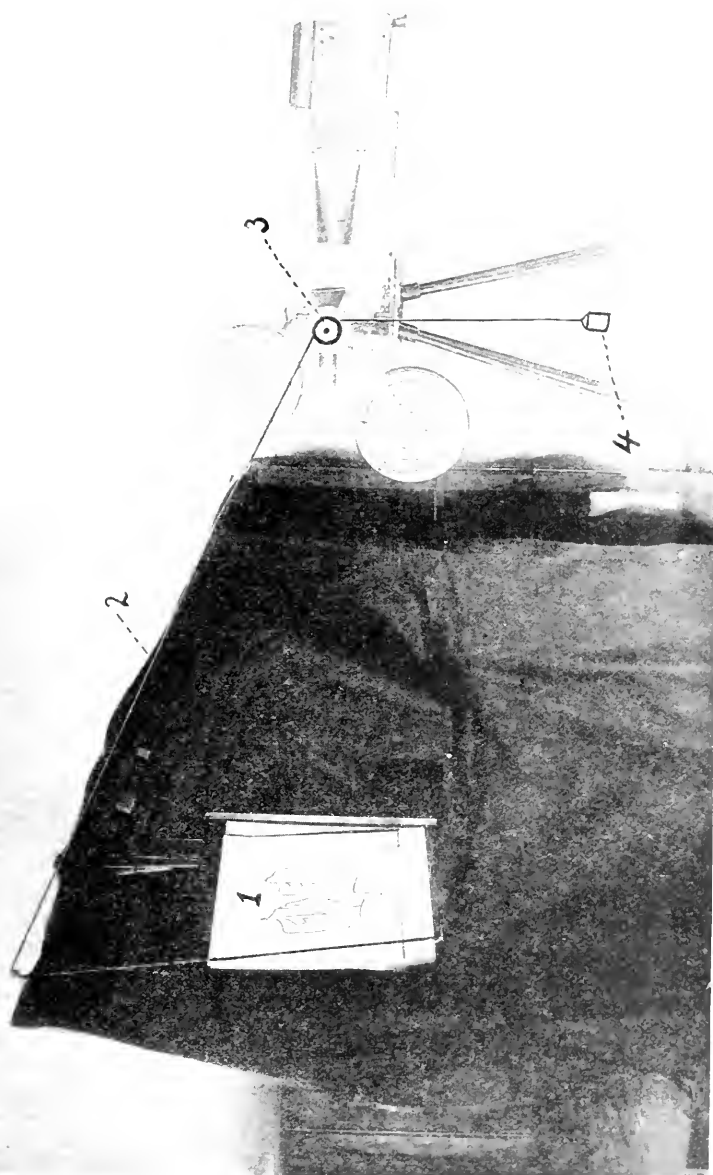


FIG. 3. General view of projection apparatus: 1, the screen on which the image was projected; 2, the string by which the operator advanced the film; 3, the ratchet wheel; 4, the weight which operated the ratchet.

A 500-watt nitrogen lamp was used in the projection machine. The heat from this lamp would have been sufficient to burn the film if care had not been taken to keep the lamp in such a position that the focal or burning point of the light did not fall on the film. The film was accordingly given what is called flood light. The machines as used in the ordinary projection have a shutter which excludes the light from the film when the film is stationary. In addition to this precaution the beam of light was cooled by a water bath (not shown in the figure).

Since the projection enlarged the image on the film many times, a very slight difference in the position of the film at successive pictures was magnified on the screen. It was necessary to make the screen easily adjustable so that the successive images could be made to fall on exactly the same place upon it. To this end a frame was constructed which supported a board in a vertical position and allowed it to be moved easily in a vertical or horizontal direction or to be rotated. The weight of the board was supported by counterweights so that it remained in any position in which it was placed. Sheets of paper (Fig. 3, 1) on which the drawings were to be made were tacked to this board.

In order to facilitate superimposing one picture on the next, reference lines were drawn on a sheet of drawing paper which was fastened to the table on which the subject wrote.

The projection screen and the space between it and the lens of the projection machine were enshrouded with a hood to make it possible to work in a light room in daylight.

In the study and measurement of the various aspects of the photographs it was always convenient and sometimes necessary to have on the screen a facsimile of the written record which the subject's pen had left. This could have been traced from the motion-picture photographs themselves, and in fact this method was pursued in the beginning. But the much more convenient and accurate method was soon hit upon of photographing the original writing specimens with a degree of enlargement corresponding to the enlargement of the films by the projection machine. These photographic prints were then pasted on the sheets of paper on which the projection was to be made.

THE METHOD OF STUDYING THE RECORDS

The preliminary study of the motion-picture films was made by running them slowly through the projecting machine and making a cursory examination of the outstanding features of the writing movement of the various subjects. This inspection revealed the more striking features of the hand position and movement and indicated the direction it would be profitable to take in the more exact and detailed study of the records.

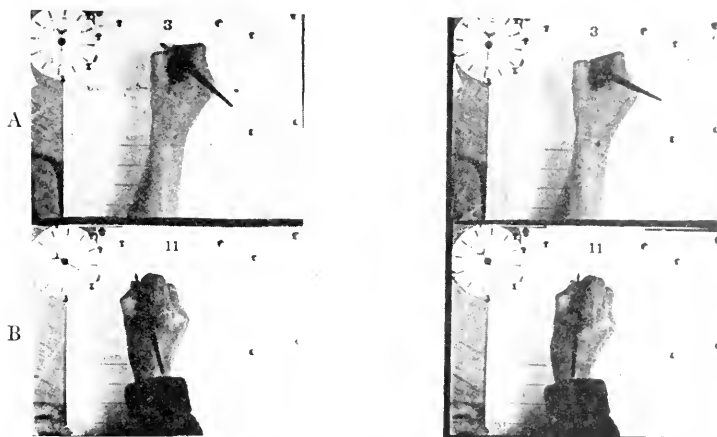


FIG. 4.—Specimen photographs of the hands of two writers showing A, the position at the top and bottom of a letter and B, the position at the beginning and end of a word.

This more exact study was carried on, first, by making drawings of the hand at certain crucial points in the writing. The points which were chosen were the top and bottom of the tall letters, in order to indicate the kind of movement employed in making the up and down strokes, the beginning and end of a word, and the beginning and end of a line of writing across the page, in order to indicate the type of movement by which the hand was carried across the page. Specimen photographs from which the drawings were made are shown in Fig. 4. The method was to superimpose two drawings in order to facilitate the comparison of the two positions. The two superimposed drawings from the subject shown in the lower photographs are given in Fig. 15, page 53. It is clear

from this drawing that the movement by which the hand was carried along while the letters of a word were being formed was one chiefly of the wrist.

These drawings, supplemented by direct observation of the projected images of the films, are the source of other observations on the hand position. From them the manner of holding the pen can be seen. For example, it can be determined whether the forefinger is situated nearer to the pen point than is the thumb, or, as is sometimes the case, whether it is drawn upward on the penholder so as to be opposite the thumb. Similarly, the manner in which the forefinger and the thumb are bent, which indicates something of the looseness or tightness of the grasp, may be observed. The position of the pen and penholder can be studied. It may be noted whether the pen is held so that the two points bear upon the paper equally, whether the penholder is held opposite the knuckle joint or is allowed to drop into the angle at the base of the thumb, and whether the holder points along the forearm or to the right or the left. Furthermore, the degree of pronation of the hand (turning the palm down) may be roughly measured. If the hand is entirely prone, the wrist is level. A nearly level wrist is commonly regarded as a necessary feature of good position. To some extent the manner in which the hand is supported—for instance, on the third and fourth fingers or on the side of the hand—may be discovered. Finally, the position of the arm is revealed, whether it is approximately at right angles to the line of writing or inclined to the right or left. On the basis of the observations on these points the writers were classified and the relationship between the hand position and skill in writing was worked out.

The method of recording the speed changes was simple. The photograph of the subject's writing produced under the motion-picture camera was pasted on a sheet of paper and placed on the projection board. The first photograph of a record was then projected, and the board adjusted so that the image of the pen point coincided with the beginning of the first stroke of the word. The guide lines or other reference lines were drawn on the paper. The position of the pen was indicated by a short check line on the letter stroke. The film was then advanced until the next section con-

taining the second photograph was in position, and the board was adjusted until the stationary parts of the photograph (at this early stage, the guide lines) coincided with the lines on the screen. If the pen point had moved, its new position was indicated as before. If it had not moved, as was usual at the beginning of a word, a count was kept of the number of exposures after the first one which elapsed before the pen moved, and this number was written opposite the mark which indicated the position. The completed record is illustrated in Fig. 5. It is obvious that a crowding of the points means a slowing down of the movement, that their spreading means an acceleration, and that the numbers indicate pauses. The time

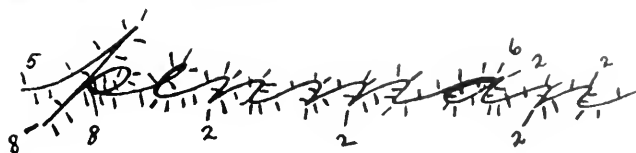


FIG. 5.—Illustration of a record of the speed changes in writing

unit by which the duration of the pauses is measured is one exposure of the camera, which was usually one twenty-fifth of a second. A further method of charting the speed changes will be described in connection with the individual records.

THE SUBJECTS

The subjects of the intensive laboratory experiment included fifty children and adults. The children were chosen from two schools, the University Elementary School and the Ray School, a Chicago public school. The two groups together furnished good material for the experiment because they included one group of children who do not have much highly specialized instruction in writing, and another group made up of those who receive regular drill in one of the well-known arm-movement systems of writing. In the University Elementary School no system is used uniformly throughout the school, and the method and amount of training are left largely in the hands of the individual teachers. In some grades regular writing exercises are given and in others there is little instruction in this subject. In general, large latitude is given to

individual variation. In the Ray School regular drill is given. This range in the kind of instruction which the children received made it possible to study the effects of instruction and also such distinctions between good and poor writing as may be independent of the influence of the method of teaching.

From these two schools children were chosen who represented extremes of good and poor writing. Writing tests were given in both schools and the selections were made on the basis of the papers which the pupils wrote. From each grade of the University Elementary School four of the poorest and one of the best writers were selected. From the Ray School four good and four poor writers were selected from each of the fourth and the eighth grades. Fourteen of the poor writers in the University Elementary School were photographed and then were given special instruction in writing and at the end of this special training were photographed.

The adults were selected with the purpose of getting representatives of good and poor writers. The effort to find poor writers revealed the fact that the nature of writing deficiency differs somewhat in adults and children. The deficiency in children seems to be more largely a matter of deficient motor control, while among adults it seems more often due to rapidity and the lack of minute attention to detail. A number of relatively good and relatively poor writers, however, were obtained from among the students of the School of Education. In addition to these a number of persons who may be called professional writers were photographed. Three of these had not had intensive training but are employed as addressers by the University of Chicago Press; another, Mr. C. P. Zaner, is the well-known teacher of penmanship and publisher of manuals.

CHAPTER III

ANALYSIS OF INDIVIDUAL RECORDS FROM THE MOTION- PICTURE STUDY

STUDY OF ILLUSTRATIVE RECORDS FROM ADULT WRITERS

We shall begin our study of the results of the laboratory experiment by an account of a few typical records which are chosen to represent the various groups of writers. This will give a clearer idea of the handwriting habits of individual writers than can be obtained from the study of tables, and will prepare the reader to appreciate the variety of ways in which the different elements of position and of movement may be combined in different individuals. The conditions of good writing are several, and rarely does one writer exhibit them all. Good writers usually have some unfavorable characteristics and poor writers are not usually so hopeless as to have no redeeming traits. It is only after a study of a number of individuals, therefore, that the characteristics which belong to good or poor writing gradually emerge. This difficulty in discrimination is particularly present in the study of the writing of educated adults, most of whom have overcome by long practice the grosser faults which appear in the writing of children.

THE POSITION AND MOVEMENT OF A WRITING EXPERT

Figs. 6 and 7 give a reproduction of a part of the writing which Mr. Zaner produced under the camera and the speed records that were made from it. This, as well as all the work which will be shown, was done without special preparation and with pen, ink, and paper which were provided in the laboratory.

Three styles of writing are shown. The first line, consisting of the words "professional penmanship," will be recognized as appropriate to set before the pupils as a copy. The second line is somewhat less precise and the third line still less so. Since our aim is the practical one of discovering the conditions of the sort of writing which is in general use, we shall make our especial study of the informal handwriting shown in the third specimen.

From the photographs which were made during the writing of this line drawings have been made to illustrate the important phases of hand position and the grosser aspects of movement. No drawing can give as vivid an idea of the details of the movement and position as can be obtained from the observation of the motion pictures themselves, but the drawings have the advantage of making possible the more exact representation of the facts.

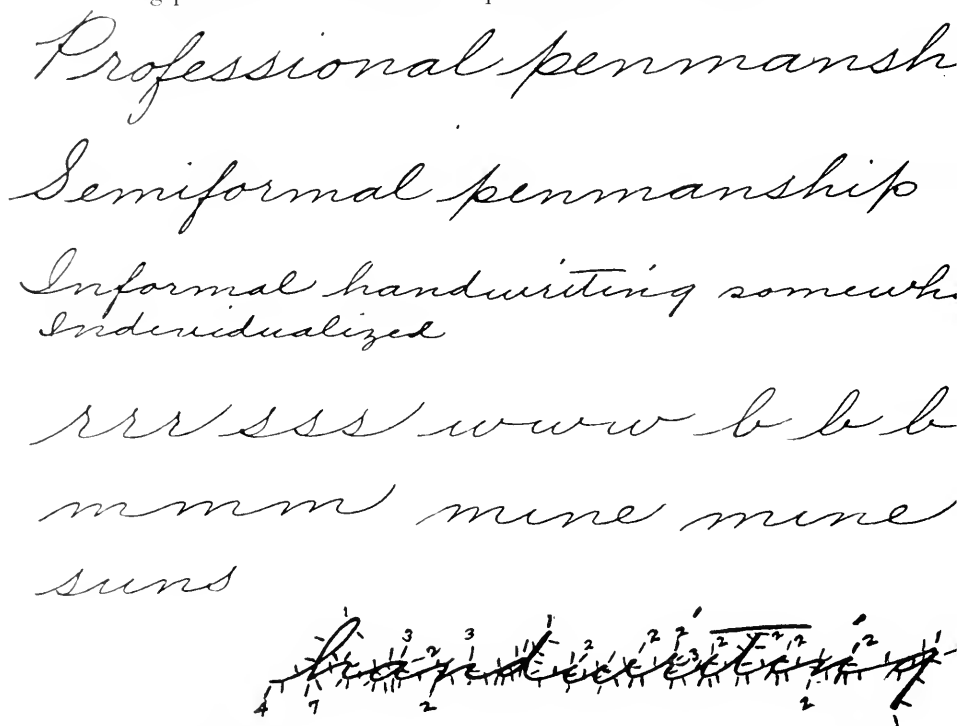


FIG. 6.—The writing of C. P. Zaner and the analysis of the speed on one word

Observe, first, the position of the hand and arm as they appear in Fig. 8. The full-line drawing on the left represents the position of the hand at the beginning of the word "handwriting." The elbow is situated slightly to the right of a line drawn perpendicular to the base line of the writing, and as a consequence the forearm inclines slightly to the left. This is somewhat at variance with the theory which is sometimes held, that the forearm should be perpendicular to the base line.

The hand is turned over somewhat to the right so that the wrist is inclined about 30° from the horizontal. It was formerly held that the wrist ought to be level, but few make this requirement now.

The drawings themselves do not show directly the manner in which the hand is supported, since the mirrors giving front and side views of the hand were not used when these records were made, but it is evident from an inspection of the position of the hand and from the manner in which it is carried along the line that the hand is supported on the first joints of the third and fourth fingers, on

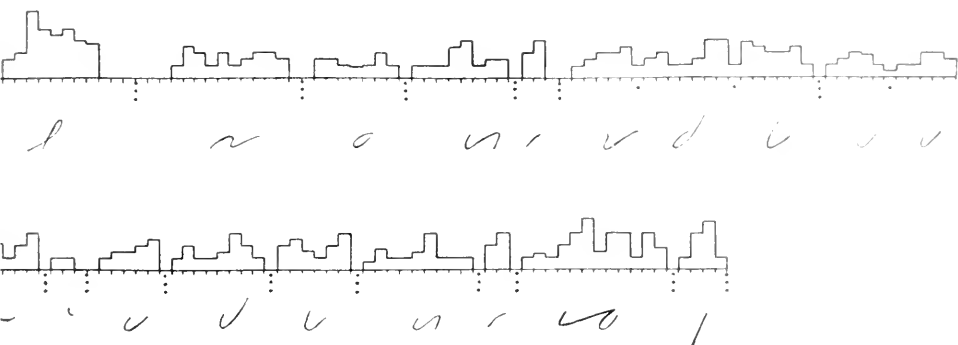


FIG. 7.—Speed curve from the word "handwriting" written by C. P. Zaner

which it slides during the formation of the letters and the movement from one letter to another.

As a result of turning the hand to the right the penholder points nearly in the direction of the forearm. This is not much at variance with the customary directions at the present time, but it is at variance with the former rule that the penholder should point toward the right ear.

The penholder is grasped in an easy manner by the thumb and the first two fingers. The first finger rests on the top of the penholder and the thumb presses lightly against the side at a point farther from the pen point than the finger. The penholder rests in a hollow between the thumb and the first finger. The older belief was that the holder should bear against the knuckle of the index finger.

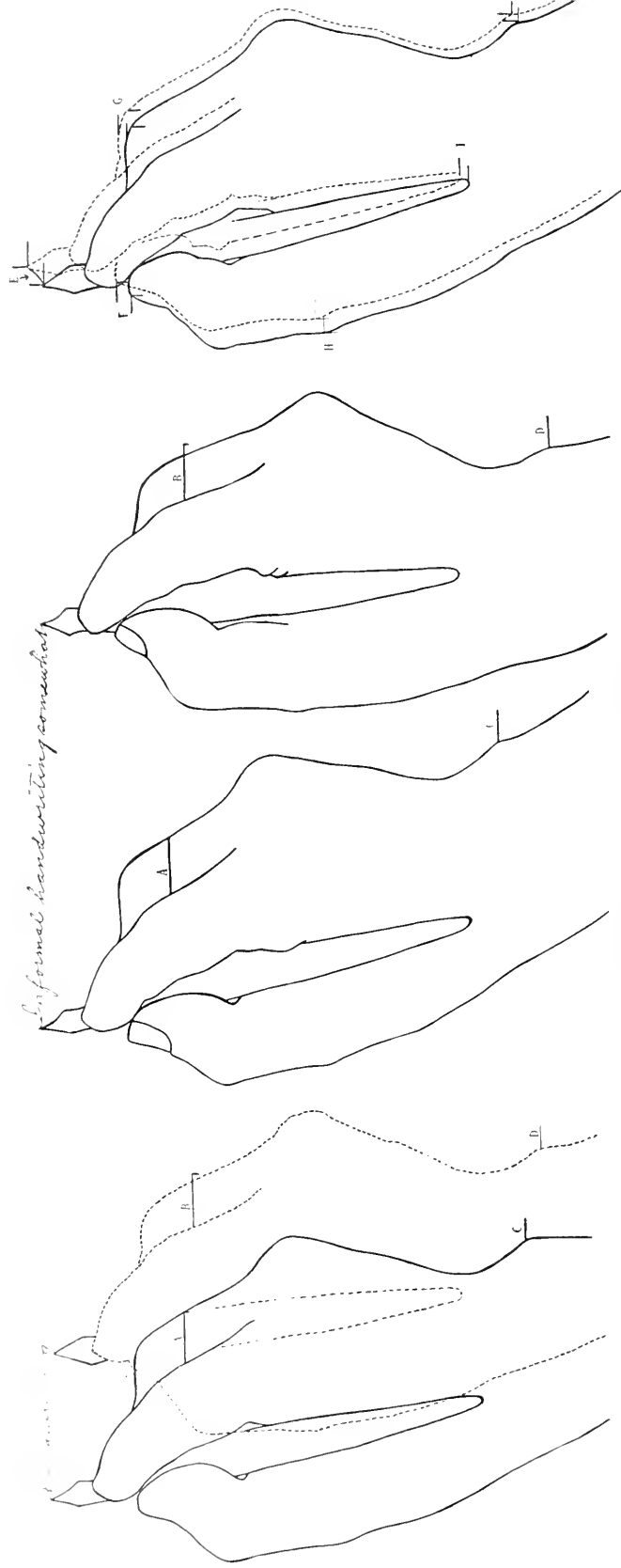


FIG. 8.—Hand position and gross movement of C. P. Zaner

It is not surprising to find the professional expert's position conforming to a liberally interpreted orthodoxy. This does not prove that good writing *cannot* be produced when the canons of strict orthodoxy are still more radically disobeyed. We shall have to examine other good writers, not to be classed as experts or professional teachers, to see what variations may occur and still permit the writing to be good, even though not the best. But we may, provisionally at least, take the position of the expert as the standard.

We may next examine the composition of the movement, that is, the elements of the hand and arm movements which make up the total movement. The writing movement may for convenience be analyzed into two components or elements: (1) the sideward movement by which the hand is carried from left to right across the page, and (2) the more complex movement of forming the letters.

The sideward movement is fairly well indicated by comparing the position of the hand and arm at the beginning and end of a word or at the beginning and end of a line. The left side of Fig. 8 shows the position of Mr. Zaner's hand at the beginning and end of the word "handwriting" and the middle section the position at the beginning and end of a whole line of writing. Where necessary to make it distinguishable the second position of the hand is indicated by a broken line.

The noteworthy fact about the movement of this writer's hand along the line is the uniformity in the position of the hand which is maintained. The direction of the penholder, for example, is kept almost the same, so that it remains parallel to the initial direction throughout. This uniformity is doubtless a condition of the uniformity of slant of the letters. The apparent manner in which the penholder is kept parallel to its initial position is interesting. The forearm does not remain parallel to its initial position, but the elbow retains approximately its original position, while the hand moves forward. The arm therefore points more toward the right at the end of a line or of a word than at the beginning. This is quite evident in the drawings. The penholder, in order to maintain its position with reference to the paper and the writing, has

been altered in position so that it points along the arm at the end of the line, whereas it pointed to the left at the beginning.

A further study of the drawings indicates the method by which this adjustment was made. If a line *A* (Fig. 8) is drawn from the edge of the index finger to the edge of the middle finger in the left-hand drawing, and a line *B* of the same length drawn from the edge of the index finger on the right-hand drawing, it becomes evident that the outlines of the two fingers are closer together in the right-hand position. This is evidence that the hand turned over toward the right as it progressed along the page. Further evidence of this is seen in the position of the index finger on the penholder and in the appearance of a space between the penholder and the second joint of the thumb at the end of the line. Thus one change in the position of the arm as the hand moves across the page is accompanied by another sort of change which compensates for the first. This is the opposite of the movement of pronation which was observed in an earlier study.

One other adjustment of the arm, which is connected with the fact that it points toward the left at the beginning of the line, is worthy of mention. It is clear that if the elbow remained in exactly the same position throughout the line, the line would slope upward on the paper. But by comparing the position of the corresponding parts of the hand at the beginning and end of the word or the line—as indicated by the lines *C* and *D* at the wrist joint, for example—it is evident that the elbow has been drawn back. This probably did not necessitate lifting the arm or sliding the sleeve on the desk, since the play of the skin of the muscle pad of the forearm in the adult allows a movement of about an inch. The amount of adjustment of this sort necessary to keep the line straight would be less if the forearm were perpendicular to the line of writing at the middle of the page.

The movement which is employed in forming the letters is illustrated on the right side of Fig. 8 by drawings of the hand at the bottom and top of the upstroke of the letter *h*. To facilitate estimates of the movement of various parts of the hand in the vertical and horizontal directions, vertical and horizontal lines have been drawn at points *E* to *J*.

The drawings indicate that this stroke was made by a combination of the movement of the whole arm and the extension of the fingers and thumb. The stroke is made diagonally upward and toward the right. Each part of the hand and wrist which can readily be identified also moves upward and toward the right. But the amount of movement at the wrist (*J*) is only about half the movement at the pen point. The middle joint of the second finger (*G*) makes as much movement sideward as the pen, indicating some movement at the knuckle, but it does not make as much vertical movement, indicating that the pen movement is partly produced by the straightening out of the thumb and fingers.

The foregoing analysis has shown that the handwriting movement is a complex of a number of elements. A noteworthy feature of the movement of the writer whose records we are studying is the great smoothness with which the elements work together in complete co-ordination. This aspect cannot well be shown in the drawings, but it is evident in the motion picture itself. The different elements of the movement fit together so smoothly that it is sometimes difficult to distinguish them. Some of the other writers whom we shall study furnish sharp contrasts to this. Their movements are irregular and jerky, and frequently one phase of the movement, for example, the movement along the line, has to be interrupted while another movement, the formation of letters, is being carried out.

This consideration of the smoothness and harmony of the movement introduces us to the speed analysis of the writing, for it is here particularly that the contrast between well co-ordinated and poorly co-ordinated movement manifests itself. Two outstanding contrasts will appear from the study of the speed changes in writing. The first contrast is between the type of transition from slow to rapid movement and from rapid to slow movement which makes the movement jerky and irregular or which, on the other hand, makes the movement smooth and regular. The second contrast is between the speed changes which are suitable to the form of the letter to be produced and those which are not. We may examine the latter point first.

The clearest and most convenient way to represent the speed changes in writing is to indicate them directly on the writing itself. This may be done, as was shown in Fig. 6, by indicating the position of the pen point at each successive unit of time. The unit of time which is represented is the interval between one exposure of the film and the next, which in most cases is about one twenty-fifth of a second. The interval in any particular record is constant, which is sufficient for the analysis about to be made. The speed of the movement, then, corresponds to the distance between the short cross-lines. When the cross-lines are widely separated the movement is rapid. The record in Fig. 6 indicates that at the beginning of the *h* there was a pause of four exposures, or four twenty-fifths of a second. The pen then rapidly traced the upstroke, slowed down somewhat at the top, traced a rapid downstroke, and paused for seven exposures at the bottom. The rapidity of the movement is greatest in the middle of the stroke. The speed of the movement is commonly most retarded at the sharpest turns or changes of direction of the stroke, though this rule has its exceptions. Two noteworthy exemplifications of the rule are to be found in both *n*'s. The second turn at the top of each letter is made pointed, and correspondingly there is a pause at each point, while the rounded turns are made without pauses. We have here, then, in the individualized writing of an expert, examples of modifications in the form of the letters corresponding to deviations from the type of speed changes which is suitable to the production of the standard letter. Another illustration is to be found in the undue lengthening of the connecting stroke between the *n* and the *g*, corresponding to the unusually high speed of this stroke; for it is another rule that, particularly in adult writing, the longer the stroke the greater the speed with which it is made.

The speed of the stroke reflects also the complexity and the accuracy of the adjustment to be made. An illustration of this fact may be seen in the *a* and in the first part of the *d*. The body of the *a* stands out rather conspicuously as being slower than the strokes of the other letters. If one examines this letter he will see that the adjustments which are required are rather delicate. The upward stroke at the beginning must be curved and the down-

ward stroke must curve in the same degree. The next upward stroke of the *a* must be so accurately adjusted in length that it just reaches the end of the first stroke. The same is true, in a measure, of the first part of the *d* and of the corresponding part of the *g*. The continuance of the upstroke in the *d*, however, constitutes a difference which is reflected in its greater speed. The *g* in the word which is before us offers a negative illustration of the principle of the relation between speed and form. It is not retarded in speed as the *a* or the *d*. Correspondingly, the letter is not so accurately formed as are the two preceding ones. The first upward stroke, instead of being curved, is straight, and the loop is made much narrower than usual, due to the fact that the downward stroke and the upward stroke are nearly straight lines. Thus speed changes have a marked influence on form.

Another illustration of complexity is to be found in the *r*. At the top of the *r* the form is similar to the *i* and a number of other letters. This part of the *r* is not to be distinguished from similar parts of other letters. The shoulder of the *r*, however, requires a double change in direction within a short distance, and it typically requires a retardation in speed which is out of proportion to the amount of change in direction which each turn by itself involves.

The tendency in adult handwriting is to slur over such complexities as these. This is done by falling into a rhythmical movement in which the successive strokes are made in nearly the same length of time. This tendency to a simple type of rhythm is characteristic of developed and mature writing, and within limits is a mark of excellence. But it must be kept strictly under control, as we shall see by further illustrations, or it will result in a deformation of the letters. This fault is more prevalent in adult writing than in that of children.

Another fact to be observed in the specimen of writing before us, which may be of some significance, is the difference in speed of the upward and downward strokes. The upward strokes are usually made more rapidly than the downward strokes. This, as well as certain other features, may be seen more clearly in Fig. 7.

This chart is constructed after the following manner: Each horizontal unit represents one exposure of the camera or one

twenty-fifth of a second. The height of the column above each unit represents the distance in millimeters which the pen traveled during the corresponding camera exposure. The absence of a column indicates a pause of one twenty-fifth of a second. For example, we find in Fig. 6 that four exposures of the camera were recorded at the beginning of the word "handwriting." One of these is reckoned as simply representing a stage in the movement, as do the exposures where there is no pause, and the remaining three are taken to represent the duration of the pause. This pause is indicated on the speed curve in Fig. 7 by the horizontal line at the beginning, three units long. During the next exposure of the camera the pen traveled a distance which is measured by one and one-half millimeters on the enlarged specimen in Fig. 6. This is indicated by a column one and one-half spaces tall.

In brief, a space on the speed curve which is left vacant represents a pause, and the extent of the space indicates the length of the pause. A series of columns represents a movement of the pen. The speed of the movement in its successive stages is represented by the height of the successive columns and the duration of the movement by the number of columns.

A pause constitutes a break in the movement, which may be regarded as marking the division point between successive units of the movement. Such division points are indicated by three dots placed vertically below the curve. For convenience in interpreting the curve the part of the letter which is made during each of these units of movement is traced underneath. Secondary divisions in the movement which are made by a retardation in speed not sufficient to constitute an actual pause are indicated by single dots underneath.

It will be observed by examining the chart that the fact which has just been stated holds; namely, that the upward strokes are usually made more rapidly than the downward strokes. The columns which represent upward strokes are usually higher than those which represent downward strokes. The significance which may possibly attach to this fact may be seen by the consideration that the upward strokes slope in general toward the right, and therefore carry the hand forward along the line. Our analysis

will show repeatedly that this forward movement and the position which makes it possible are among the important conditions of efficient writing. It would appear, then, that this writer emphasizes the forward movements by making them with greater speed than the backward movements.

The speed curve of the writing furnishes also a convenient means of studying the way in which the whole writing movement is divided into sections by pauses or retardations in speed. The sections into which the writing movement is divided by pauses may, for the most part, be regarded as the units of the writing movement. In some cases the slowing down of the movement, although not sufficient to constitute an actual pause, may be regarded as a division between two units. These units may be so organized as to be appropriate to the form of the letters which are being produced or so as to be inappropriate.

It appears that, in the writing before us, the unit of movement is usually composed of at least two strokes, one upward and the other downward. In some cases more than two strokes are included. See, for example, the unit including the last downward stroke of the *a* and the first part of the *n*. In this case two downward strokes and one upward stroke are included in one unit. This corresponds to the fact that there are no sharp turns within this part of the word. There are some exceptions to the rule that there is retardation at the sharp turns. This is illustrated by the first stroke of the *d* and the top of the upward stroke in the letters *d* and *w*. According to the common practice we should expect a pause at each of these points. At the top of the *d* there is a distinct retardation in the speed of the movement, and this should probably not be taken as a genuine exception to the rule.

An inspection of the speed curve to discover the manner in which the changes in speed are made indicates that, in general, they are somewhat gradual and that the acceleration and retardation of the movement are for the most part not abrupt. This is shown by the fact that the curve rises and falls rather gradually. There are exceptions in the cases of some of the upward strokes, such as the first stroke of the first *i*. These are illustrations of rapid movements which stop somewhat suddenly. The acceleration of

these movements, however, has been gradual, and there are no instances in which the movements begin abruptly. Some of the poor writers exhibit a marked contrast to this.

THE POSITION AND MOVEMENT OF A GOOD ADULT WRITER

We now turn to a briefer inspection of the writing of another good adult writer which is reproduced in Fig. 9. It is evident that this is good writing, although the letters are less regularly and accurately formed than those in the writing of the first subject. The hand position is indicated in Fig. 10. In the first drawing the hand is shown at the top and bottom of the downward stroke of the letter *a*. The position here is evidently much like that of the first subject, which we may regard as standard. The thumb and forefinger are drawn in somewhat more, but the hand rests on the third and fourth fingers, as is readily seen when the film is projected. The wrist is held fairly level and the arm is practically perpendicular to the line of writing. In the latter respect this subject differs from the first one. The movement along the line is made, as in the preceding case, by the whole forearm and not by the adjustment of the hand or wrist. The penholder is kept parallel to its initial position in this case also. The downward stroke of the letter is made by a combination of movements of the arm and fingers, but the movement of the fingers is somewhat less than that of the arm.

Turning now to the record of the speed changes, shown in Fig. 9, we find a series of speed changes similar to those exhibited by the first subject. The movement of the longer stroke of the *f* is more rapid than the succeeding shorter strokes. Each stroke of the *f* is made in a regular fashion, with the greatest speed in the middle of the stroke. The writing of the word is divided into definite and fairly regular units and there are no markedly abrupt changes in the speed.

THE POSITION AND MOVEMENT OF TWO POOR ADULT WRITERS

We turn now to the records of two adult writers who are contrasted with the two writers just discussed because of their poor letter forms and the poorly co-ordinated movements which they exhibit. The writing of the first of these is shown in Fig. 11. It

A quick brown fox jumps over the

dog.

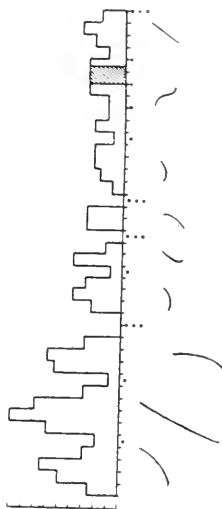


FIG. 9. Record of a good adult writer

will be admitted that there is a very distinct contrast in this writing to that of the two previous subjects. The hand and arm position and movement are shown in Fig. 12. A study of the arm and hand position of this writer indicates that it is not as sharply contrasted with that of the two good writers as is the writing itself. The hand is held with the wrist fairly level. The grasp of the pen

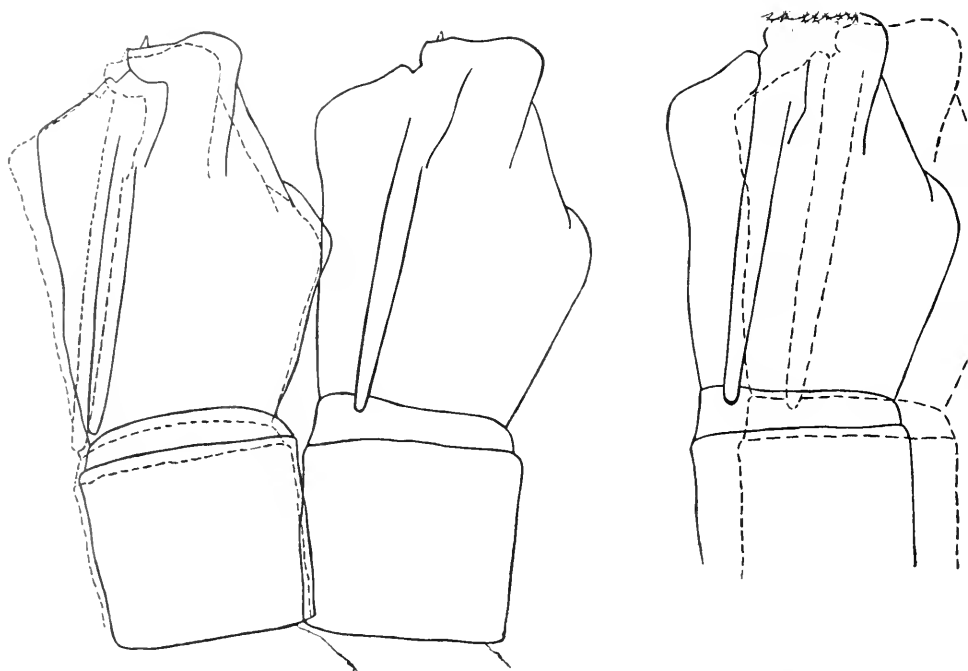


FIG. 10.—Hand position and gross movement of a good adult writer

is reasonably light and the fingers are in the position which is usually prescribed. The movement along the line, moreover, seems to be reasonably free and to be made with the arm, the hand resting and sliding on the third and fourth fingers. At the end of the line, however, the penholder is usually rotated to the left, so that the two points of the pen do not bear evenly on the paper. Another criticism of the hand position of this writer is that the penholder does not keep the same angle or direction from the beginning to the end of the writing. The consequence of this is evident in the

increased slope of the letters toward the end of the line. The writer fails to make any adjustment of the hand or arm that will compensate for the difference in the direction of the forearm as the hand shifts along the line.

This writer's habit has evidently been acquired as a result of considerable practice, and the subject in comment on this fact said that he had received considerable training in a certain well-known system of writing but that it did not "take." The downward stroke of the letter is made by the movement of the hand as a whole. This is made clear by the fact that the hand and the fingers which are not in contact with the pen are changed in position as well as the forefinger and the thumb. The notes on the observation of the projected motion picture of this writer indicate that he uses some arm movement as well as finger movement. The movement, then, is similar in its general character to that of the first two subjects, with only slightly greater emphasis on the finger element. We have seen that there are some deviations in the hand position and movement of this subject from those of the best writers as represented by the first two subjects. They are not sufficient, however, to account for the difference in the results.

A more marked contrast is to be observed in the speed changes characterizing the writing movement. These records are shown in Fig. 11. The general appearance of the speed curve indicates clearly the very erratic character of the movement. The first part of the word "jump" has been added to make this characteristic still more prominent. There is, in the speed curve, a conspicuous absence of division of movement into regular units. When we attempt to divide the word on the basis of the speed curve, as exhibited in the portions of the letters drawn underneath the curve, it is clear that divisions do not represent parts into which the word is naturally divided. Take, for example, the second unit, which comprises the last upward stroke of the *f* and the downward stroke of the *o*. The natural division point between units would be the last turn of the *f* before the connecting stroke. This turn, and the one at the top of the *o*, are passed over without the customary retardation. If we follow the movement to the next unit we see

A quick brown fox jumps over
the lazy dog.

fox jumps

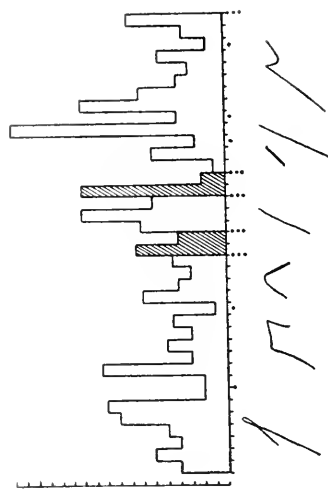


FIG. 11.—Record of a poor adult writer

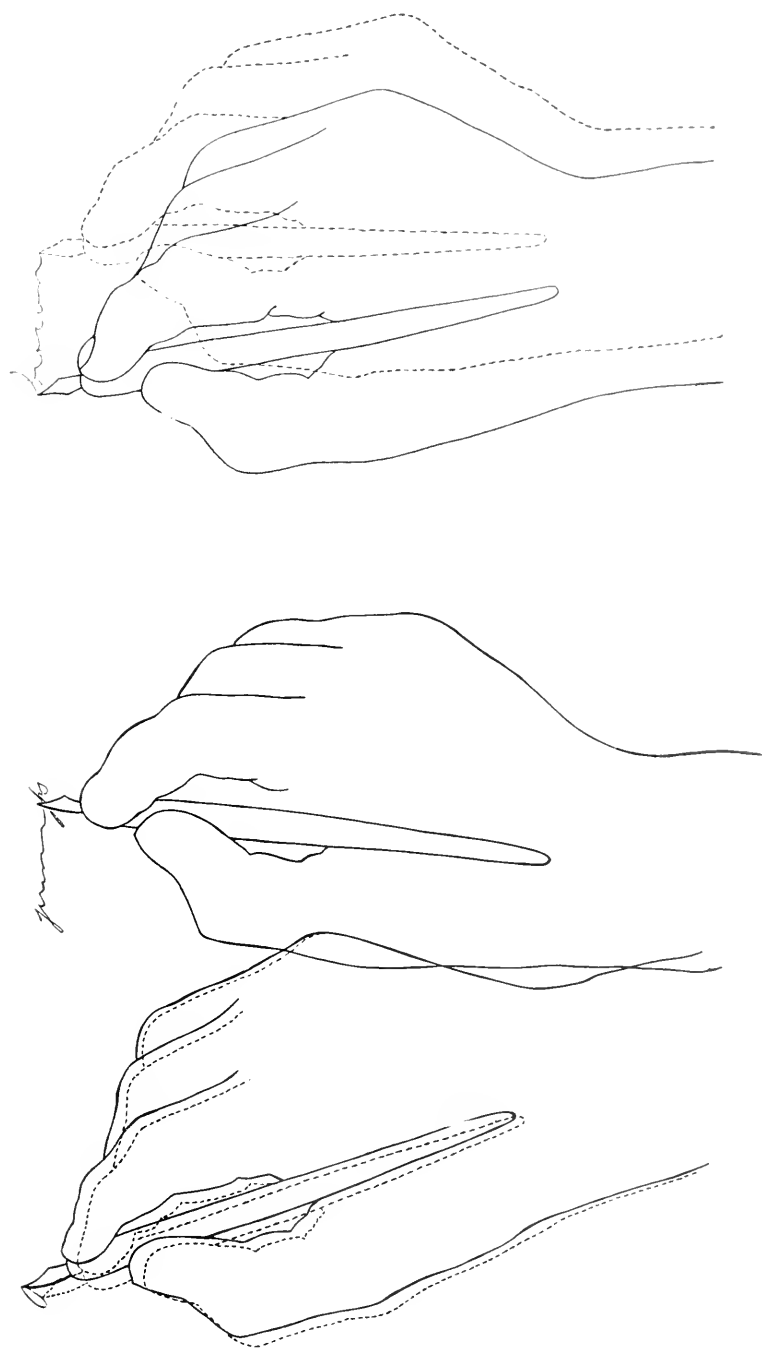


FIG. 12. Hand position and gross movement of a poor adult writer.

that the natural division point at the closing of the *o* is passed over entirely. Similarly there is neither pause nor marked retardation in the two curves of the *x*. The last stroke of the *x* is to be described more as a dash of the pen over the paper than as an orderly stroke. A clear correspondence between the imperfect division of the writing movement into units and the poor form of the letters is seen in the malformation of the *o*.

We have here, then, an extreme example of the absence of an orderly rhythmical movement, well adapted to the form of the letters that are to be produced. The training which would be adapted to this writer would not deal primarily with the factors of position or with the general manner in which the movement is made from the point of view of its composition. It would consist primarily, on the other hand, of such exercises as would lead to a rhythmical and orderly succession of movements.

The writing of the next subject (shown in Fig. 13) while somewhat better co-ordinated than that of the preceding subject, is poor for an educated adult. Figs. 14*a* and 14*b*, which show his hand position and his movement from the beginning to the end of a word and from the top to the bottom of a stroke, indicate slight departure from the position and movement of the first two subjects. The grasp of the pen and the manner in which the hand rests on the table do not show marked deviations. It may be seen from the side view, which was made possible by the use of a mirror, that the hand rests on the third and fourth fingers. The downward movement within the letter (Fig. 14*b*) is made by the hand as a whole, but the third and fourth fingers do not slide on the paper. These fingers remain stationary and the other fingers move away from them in making the upward stroke. The movement along the line (Fig. 14*a*) was evidently made by means of the arm as a whole. This is indicated by the direction of the line which represents the margin of the hand. The hand was turned palm downward when it moved toward the right, as may be seen from the angle of the penholder as observed in the forward mirror. The deviation from the usual standard in position and in the composition of the movement is not pronounced in comparison with many other writers. We shall turn, therefore, to the record of the speed changes in

order to discover whether they explain more adequately than hand position and the composition of the movement the poor quality of writing.

quick brown fox jumped
over the lazy dog.

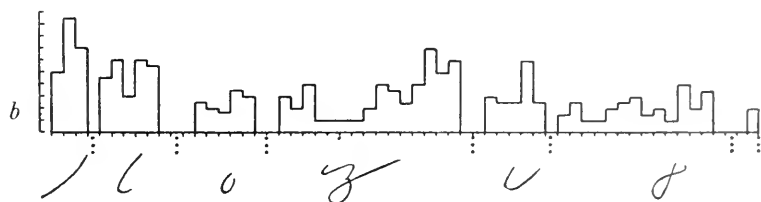
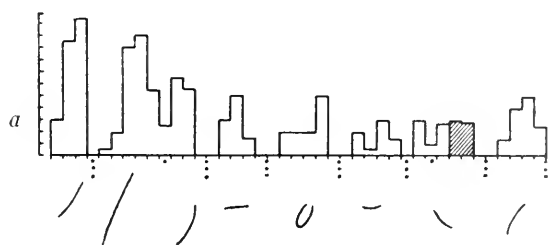
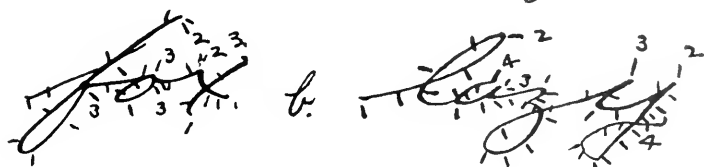


FIG. 13.—Record of a poor adult writer

The speed record of the word "fox" (Fig. 13, *a*) does not show very marked evidences of inco-ordination. There are some indications, however, that the movement is not as regularly carried out as is desirable. The first upward stroke of the *f* is more rapid than is warranted by the general speed of the rest of the word. The

acceleration and retardation in the speed of the other two strokes of this letter, furthermore, are not as regular as in the case of the first two subjects. In the *o* there is a marked contrast in the speed of the downward and the upward strokes, and the speed of the connecting stroke shows some irregularity.

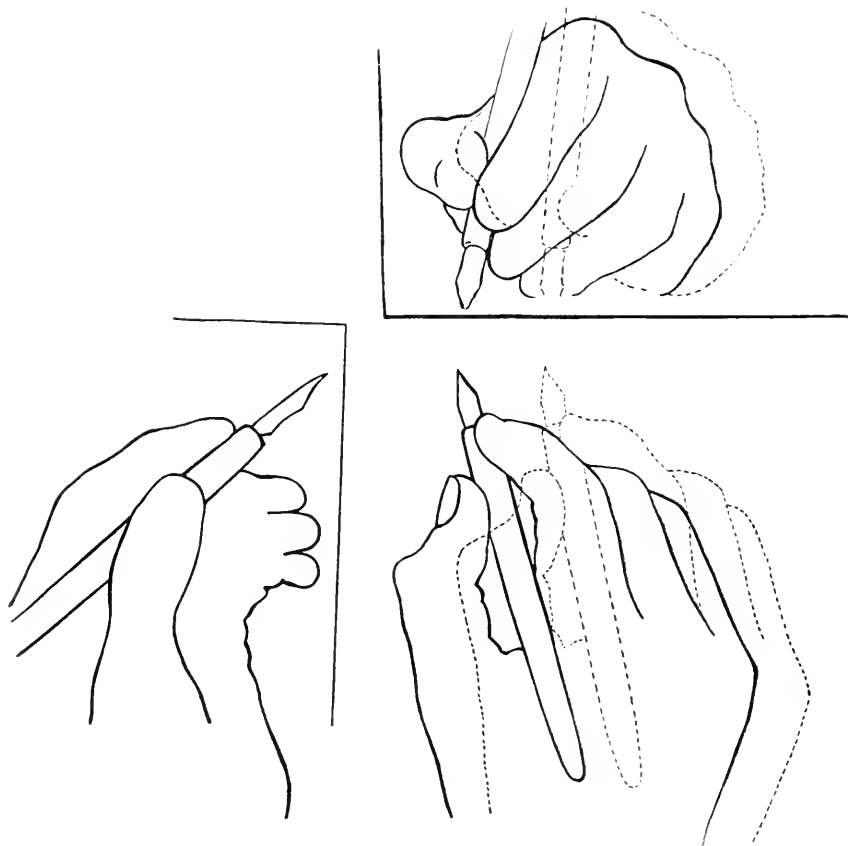


FIG. 14a.—Hand position and gross movement of a poor adult writer

In order to show a much better example of inco-ordination the record of the word “lazy,” written by this subject, is presented in Fig. 13, *b*. The unusual grouping of the strokes into units, which was noted in the case of the preceding subject, is exhibited here in the last strokes of the *a* and the *z*. The loop of the *z* would appear

to be made by a spasmodic effort, which results in increasing speed, culminating at the connecting stroke between the z and the y . After a pause at the top of this stroke excessive effort is represented by a high rate of speed until the loop of the y is reached. At this

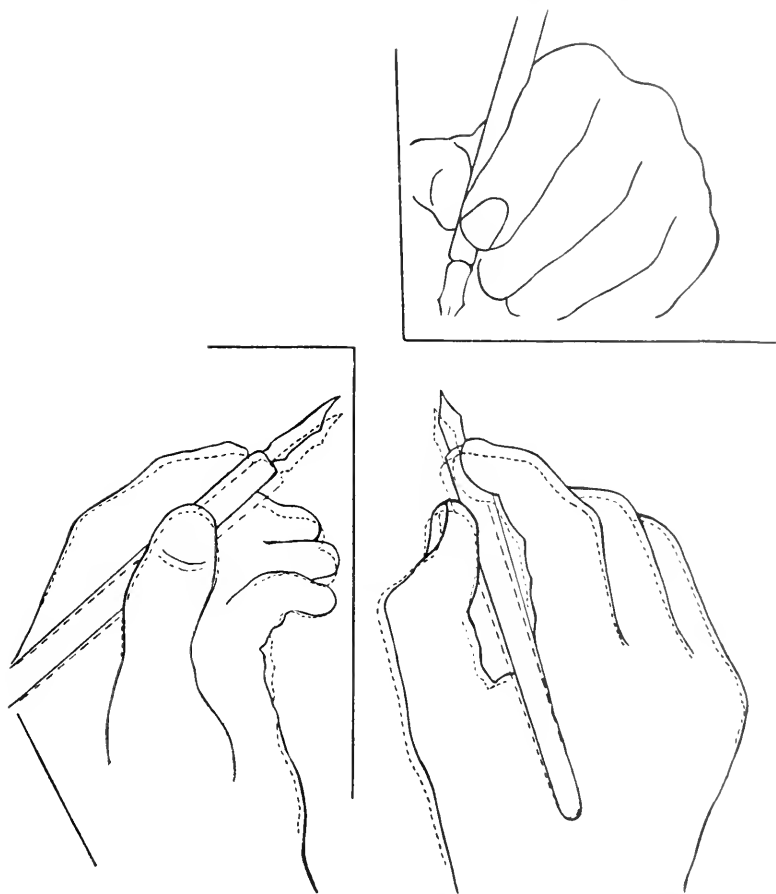


FIG. 14*b*.—Hand position and gross movement of a poor adult writer

point striking slowness and irregularity of movement appear in the speed curve, and the irregularity is reflected in the appearance of the letter itself. The whole speed curve of the word taken together exhibits a conspicuous absence of a regular succession of units of effort such as characterizes the good writer.

The only very clear distinction between the good and poor writers among these few individuals who have been taken as illustrative cases relates to the speed changes of their movement. The good writers organize the movement much more clearly into speed units than do poor writers, and these units are better adapted to the form of the letters which are being written.

ILLUSTRATIVE RECORDS FROM CHILDREN

To illustrate the writing of children we shall present representative records from good and poor writers. For this purpose the following cases are chosen: Two good and two poor writers from the upper grades, one of each group chosen from the Ray School and from the University Elementary School; also two good and two poor writers from the intermediate grades, one of each group selected as before from each of the two schools. Finally, two illustrations of the handwriting of poor writers who took special training will be given in order to compare their writing before and after training.

POSITION AND MOVEMENT OF GOOD WRITERS

The next record is that of one of the better writers in the sixth grade of the University Elementary School. The drawings of the hand position of this writer are presented in Fig. 15 and the speed curve in Fig. 16. The hand position of this subject deviates very markedly from the standard set by the good adult writers. The hand is turned so far over that it rests on the side instead of on the fingers. The movement along the line shows a large amount of wrist movement. This produces within the writing of a single word a marked change in the direction of the penholder, and this results, as may be seen in the illustration, in an overslant of the letters as the hand progresses toward the right. The hand also turns over toward the right as it progresses toward the end of the line. The index finger is drawn up so that it rests on the penholder opposite the thumb instead of below it. The movement on the downstroke of the letter is made chiefly by the fingers.

The following note on this writer was made from the observation of the film. "The error in slant is due to resting the hand on the

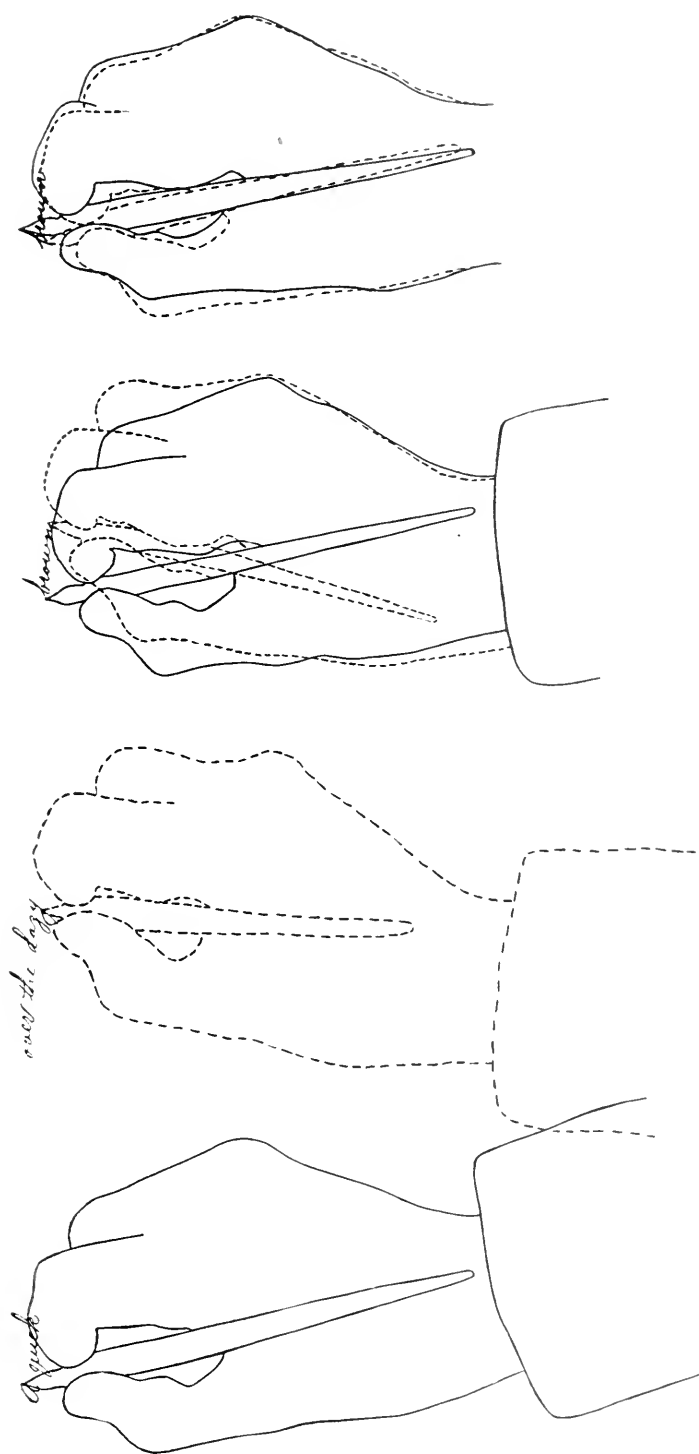


FIG. 15. Hand position and gross movement of a good writer from Grade VI



brown fox jumps over the

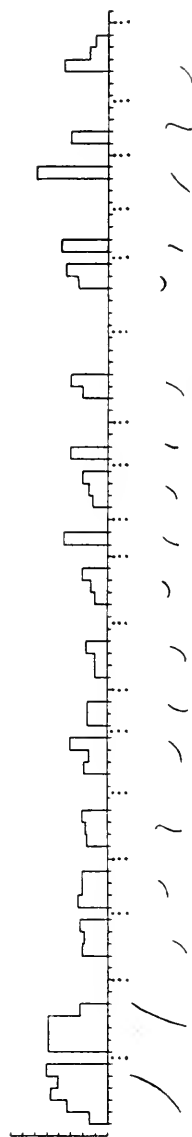


FIG. 16.—Record of a writer from Grade VI

side and to excessive wrist movement along the line. Deliberate, careful writer; needs better position for speed." The following sentence is added, which leads us to a further examination. "Bad position is compensated for by good rhythm." From the speed

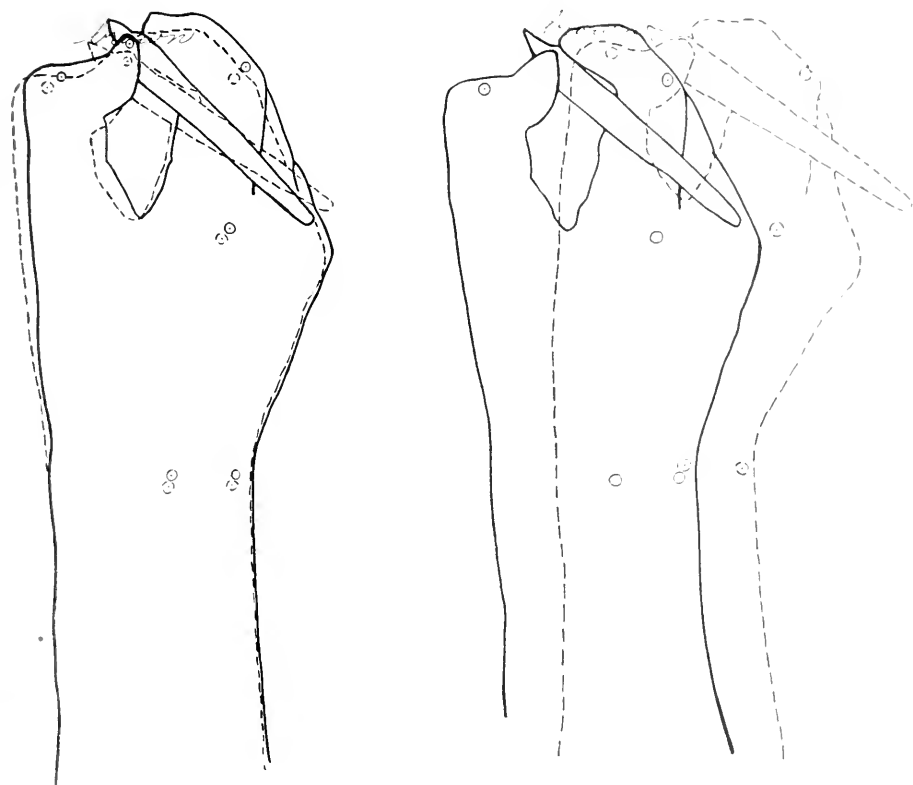


FIG. 17a.—Hand position and gross movement of a good writer from Grade VIII

curve it is apparent that this writer separates the words into units representing the successive strokes, and emphasizes the separation by rather long pauses at the ends of the strokes. The strokes themselves are made rapidly. The division into units is well adapted to the forms which are to be produced. While the rapidity with which the strokes are made gives the speed curves an appearance of abruptness, the rapid strokes are well timed and come at

places which are appropriate to the form of the writing. The movement, though rapid, is under control and does not distort the form of the writing. Slowness in this writer is due, not to slowness of the movements themselves, but to the unusual amount of time spent in the pauses. This undoubtedly aids in the control of the movement.

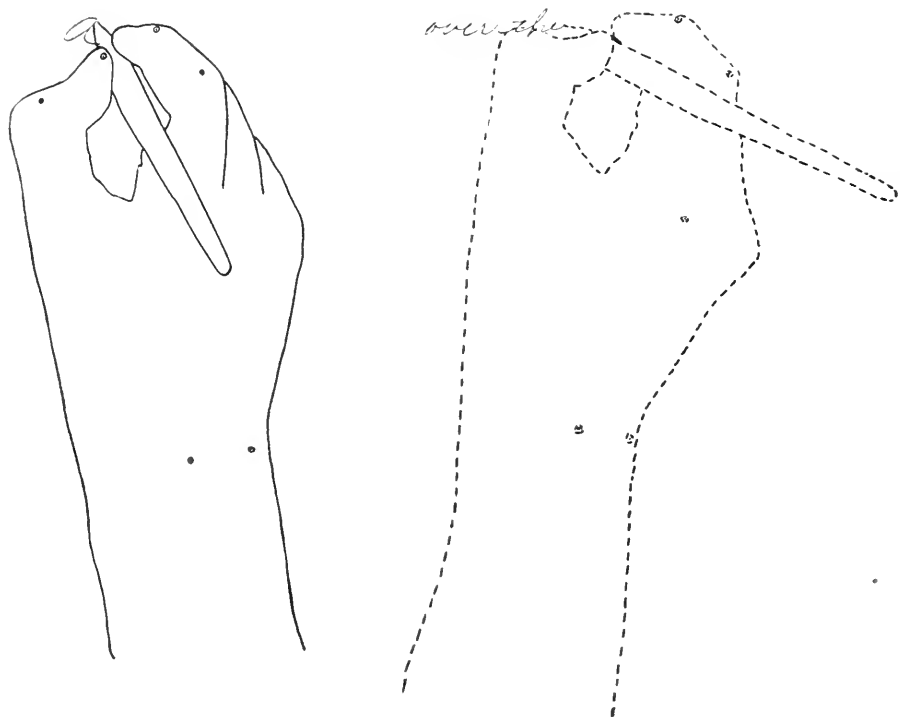


FIG. 17*b*.—Hand position and gross movement of a good writer from Grade VIII

The next subject, a good writer in the eighth grade of the Ray School, represents a radically different type of hand position and hand movement from those we have thus far observed. The hand (as shown in Figs. 17*a* and 17*b*) is turned far over to the side and the penholder is turned far to the right, being raised nearly to the second joint of the second finger. In spite of these facts the hand is supported on the third and fourth fingers and slides along the paper

easily while the letters are being formed. This may be seen from a comparison of the positions at the beginning and end of the word "brown." The movement has been made almost entirely with the arm, accompanied by a slight movement of the wrist. Toward the end of the line the hand is turned over still farther toward the right and the penholder points still farther forward. The strokes of the letters are made by the fingers with a slight accompaniment of arm movement. The fact to be remembered with reference to the position and type of hand movement of this writer is that while the hand is turned to the side it is capable of being easily moved across the page.

The speed curve of this writer (shown in Fig. 18) indicates that the writing of the word is divided into units which correspond completely to the successive strokes of the letters. These units are made with substantially the same speed, except in the case of the *b*, which, being a longer letter, is made more rapidly. The picture presented is that of a regular, well co-ordinated movement, well adapted to the forms to be produced.

The next record is from a fairly good writer in the fourth grade of the University Elementary School. The hand position (Fig. 19) again represents a somewhat extreme turning over toward the side. The hand is partly supported, however, by the fingers, and moves along the line readily, as is indicated by the fact that the arm as a whole is used to carry the hand from the beginning to the end of the word. The arm is approximately perpendicular to the line of writing at the middle of the page, and is moved along the page by turning about the elbow as a center. The finger and thumb are drawn up slightly in holding the pen, but the grasp is apparently not cramped. The strokes of the letters are made by a finger movement supplemented by a sideward movement of the arm. The sideward movement of the hand in writing the words is made by the arm and wrist, which results in some change in the direction of the penholder. This apparently is compensated for by another adjustment, since it does not affect the slant of the letters.

The speed curve of this writer (Fig. 20) is very similar to the one which has just been described. The only point at which the units of the movement do not correspond to the strokes of the

A quick brown fox jumps over

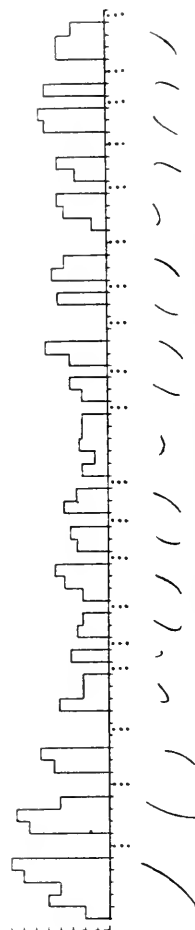
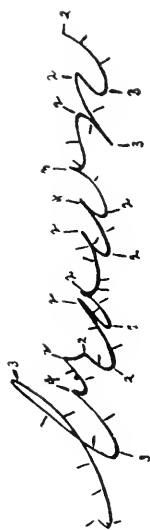


FIG. 18.—Record of a good writer from Grade VIII

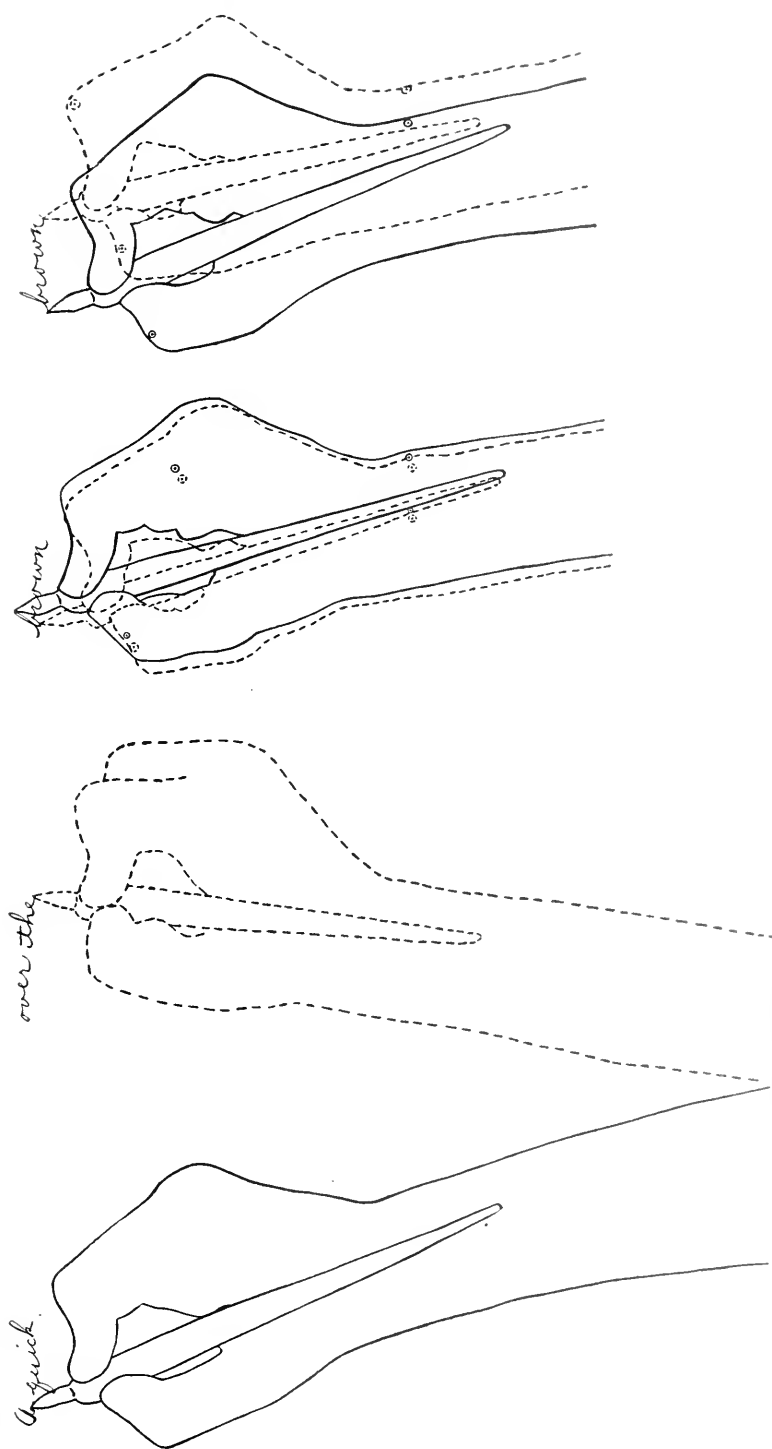


FIG. 19.—Hand position and gross movement of a fairly good writer from Grade IV

A quick brown fox jumps over the

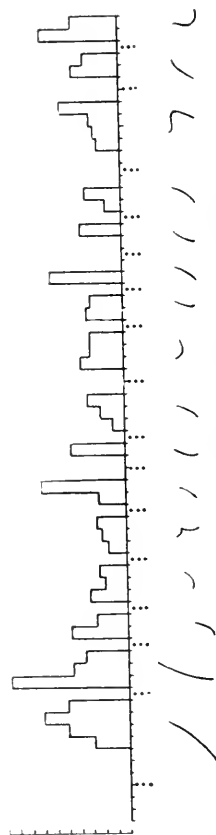
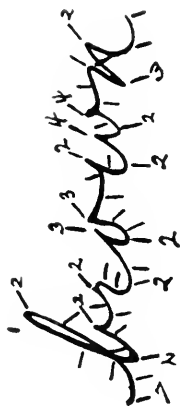


FIG. 20.—Record of a fairly good writer from Grade IV

letters is at the top of the first part of the *n*. But since this is not a radical change in direction from the connecting stroke it is not a notable variation. Another minor variation is the lack of a pause at the shoulder of the *r*.

The next record is from a good writer in the fourth grade of the Ray School. The hand position (Fig. 21) is in some respects more nearly like that in standard adult writing than is that of the subjects just described. The wrist is held reasonably level and the grasp of the pen by the fingers and thumb is similar to that which is usually prescribed. The elbow is situated at the right side of the page, which causes the forearm to slant toward the left at the beginning of the line. In consequence the arm is drawn back while the line is being written. Apparently a further consequence is the large amount of wrist movement which is employed in the writing of a word. This causes a very radical change in the direction of the penholder from the beginning to the end of the word. The hand rests on the third and fourth fingers, however, and slides easily on them while the letters are being formed. There is no resting on the side of the hand. The strokes of the letters are made by a combination movement of the fingers, hand, and arm. The relative amount of movement of the different parts is indicated by the spots which were placed on the hand and are reproduced in the drawing. The spots on the wrist move about half the distance of the whole stroke. The movement of the fingers is indicated by the fact that the thumb is more crooked at the end of the stroke than at the beginning. The fact that the hand as a whole moves is indicated by the spot on the knuckle of the index finger. This has been displaced somewhat to the left and downward. This displacement could only result from a movement of the whole hand about the wrist joint. This type of movement is not commonly recognized, but is one which is used relatively often by good writers.

The speed curve (Fig. 22) shows only slight deviations from the type that is found to be characteristic of good writers. The stroke begins in an unusual manner by exhibiting high speed at the start. The *o* and the first part of the *w* are made as single units of movement rather than as two. This, however, is frequently found among good writers and cannot be said to be a marked variation

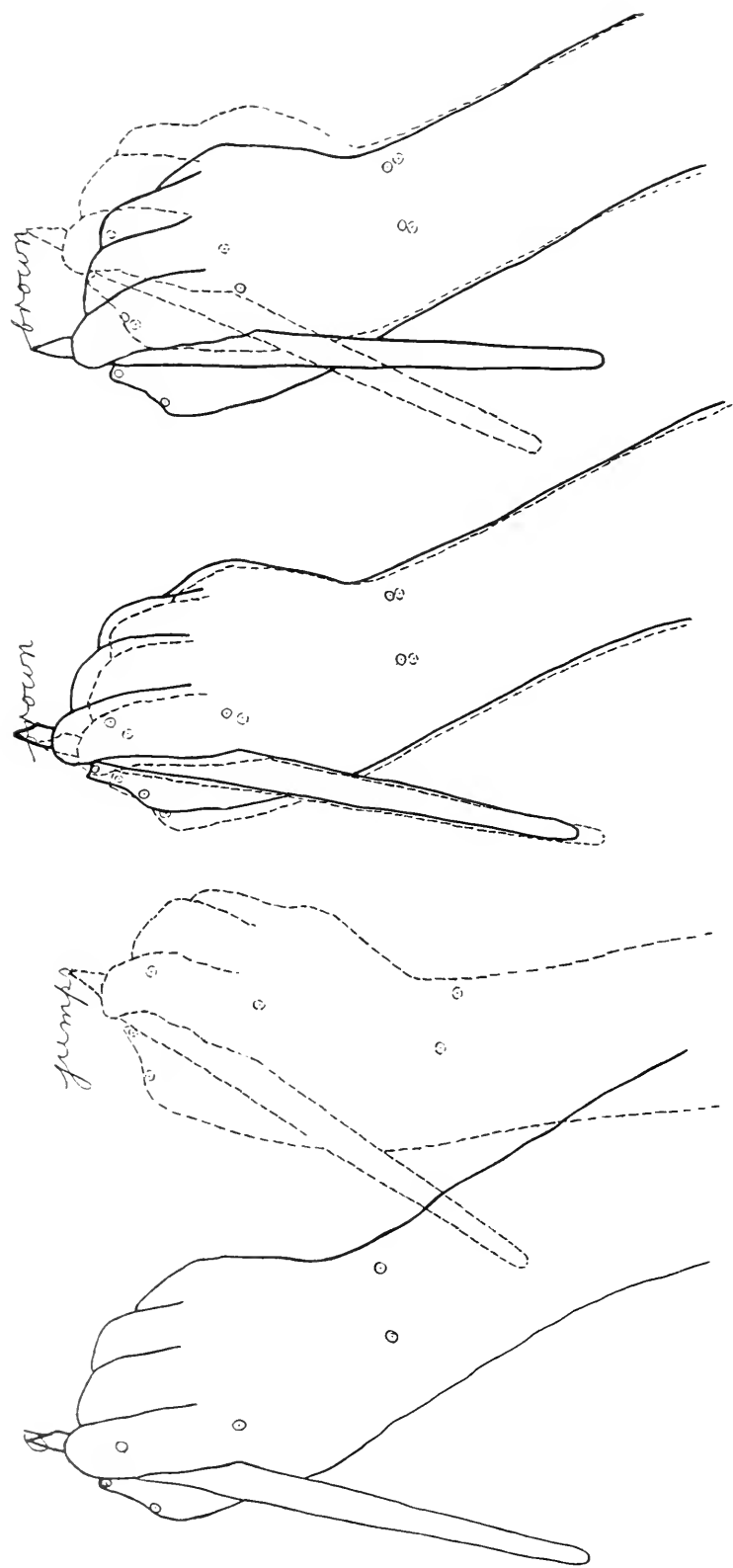


FIG. 21.—Hand position and gross movement of a good writer from Grade IV

A quick brown fox jumps

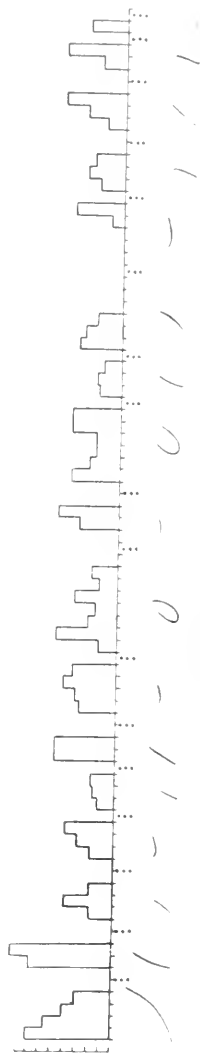


FIG. 22.—Record of a good writer from Grade IV

from the type. The rather long pause at the end of the *w* is probably the consequence of the immaturity of the writer and the incomplete development of his co-ordination. In general, however, the movement is very well co-ordinated for a pupil in the fourth grade.

SUMMARY

Before proceeding to the study of the records from poor writers we may briefly summarize the characteristics of the movement of the good writers which have just been examined. Considerable variety has been found in the three aspects—hand position, composition of the movement, and speed organization. We can therefore merely note what seem to be the prevailing types and defer their more exact determination to the statistical study of larger groups. In hand position good writers may deviate widely from the orthodox position, but it may be described negatively by saying that it is not strained or cramped. The hand does not usually rest on the side, but rather on the fingers. Even when the hand does rest on the side it slides freely across the page while the letters are being formed. The formation of the letters may be accomplished chiefly by the fingers or the arm or by a combination of the two. From the point of view of speed organization the movement is commonly divided pretty definitely into units, separated by pauses, and these units correspond to natural units of the letter forms.

POSITION AND MOVEMENT OF POOR WRITERS

How do poor writers, taken from the same groups of children as those we have been examining, compare with these good writers? The contrast may be observed in the following cases. The first is a poor writer in the seventh grade of the University Elementary School. The drawings of the hand position and hand movement (Figs. 23*a* and 23*b*) indicate that the hand rests on the side. Moreover, in the movement along the line the hand does not slide freely. This may be seen in the fact that the little finger projects beyond the arm more at the end of the line than at the beginning, and by the fact that the hand is turned farther over toward the side at the end of the line. An inspection of the motion picture indicates clearly that the hand is carried along in an intermittent fashion. We may describe this best by saying that the hand hitches at intervals during the writing of a word. More detailed drawings of the

manner in which the hand is carried along the line will be presented shortly. The forearm slopes to the left at the beginning of the line and does not quite attain a perpendicular position at the end of the line. The direction of the penholder changes radically during the writing of the line, and this is accompanied by a change in the slant of the letters. The movement throughout the writing of a

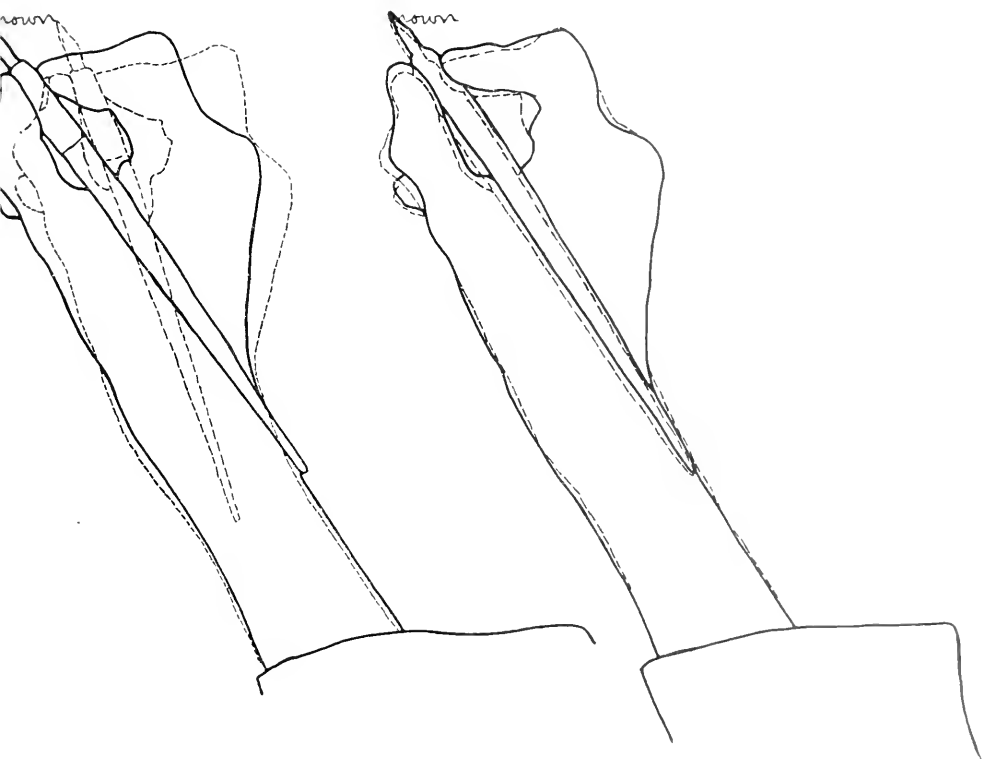


FIG. 23a.—Hand position and gross movement of a poor writer from Grade VII

single word is accomplished by a backward turning of the wrist and by a change in the angle of the penholder. The strokes of the letters are made by drawing back the finger and the thumb. The noteworthy feature about the hand movement of this writer is the lack of good co-ordination between the movements of the fingers and the arm, and this lack of co-ordination is favored by the extreme side position in which the hand rests on the table.

In the speed curve (Fig. 24) we find a marked contrast between this subject and the good writers. The writing is not divided to correspond to the strokes or natural combinations of strokes in the letters. The individual strokes themselves are not made uniformly with acceleration toward the middle, which is what we should naturally expect and find in the better co-ordinated writing.

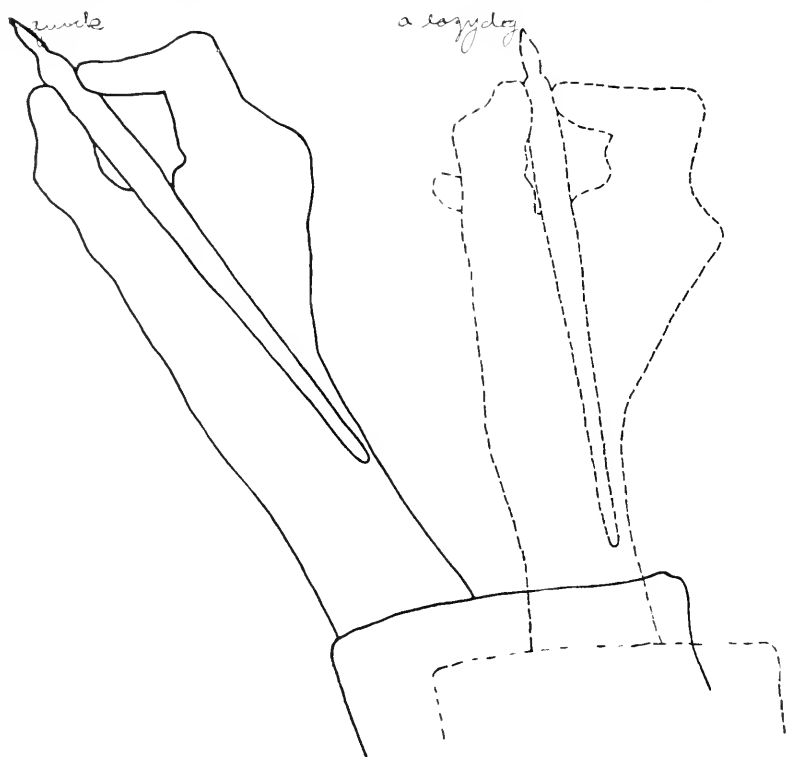


FIG. 23*b*.—Hand position and gross movement of a poor writer from Grade VII

At the very first stroke, for instance, there is a pause near the beginning, but no pause at the top of the loop or at the bottom. The bottom of the *r* is made without retardation, and correspondingly it is much too rounded. The strokes from the last bottom turn of the *w* to the first bottom turn of the *n* are grouped together, and there is a lack of proper division between the strokes. There is a marked contrast in speed between some of the

a quick brown fox jumps over a lazy dog

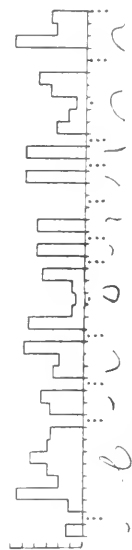


FIG. 24. Record of a poor writer from Grade VII

strokes and others. Compare the speed of the *r* and the middle part of the *o* with the first half of the *w*; or the *b*, which should be comparatively rapid, with the last part of the *n*, which should be slower. This writing exhibits a general lack of uniformity, accompanied by a lack of adaptation of the speed to the letters which are to be formed.

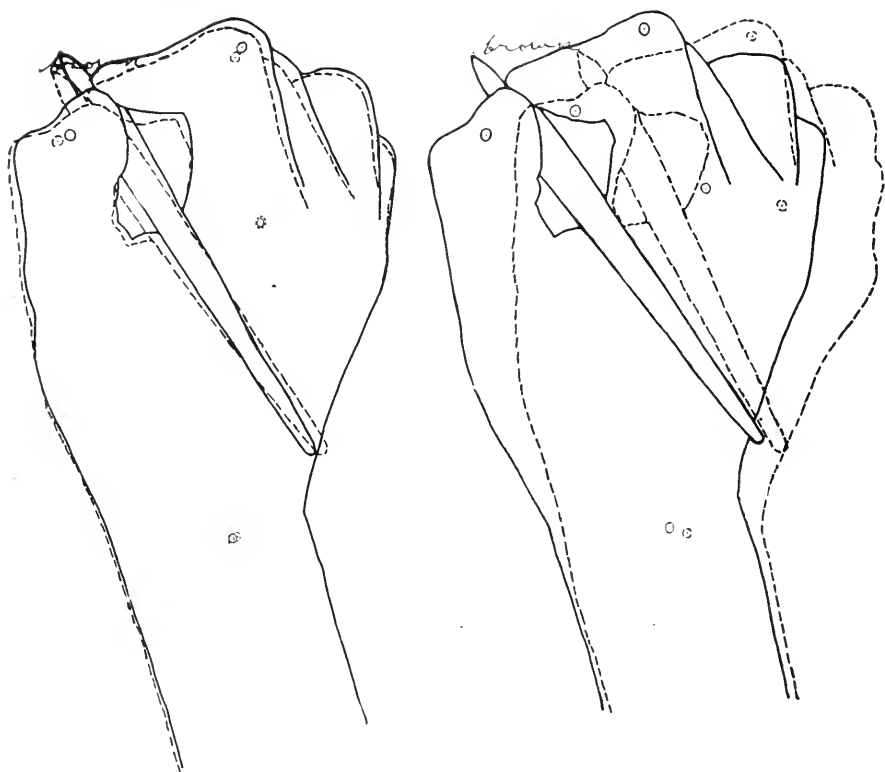


FIG. 25a.—Hand position and gross movement of a poor writer from Grade VIII

The next record is from a poor writer from the eighth grade of the Ray School. The hand of this writer (Figs. 25a and 25b) is turned over on the side, but in spite of this the movement along the line is somewhat freer than that of the preceding subject. This is indicated by the fact that there is some movement of the arm as well as of the hand from the beginning to the end of a word. The move-

ment is more successful at the beginning than at the end of the line, as is shown by the deterioration in form. Corresponding to this deterioration in form there is evidence of some cramping of the hand. This involves an adjustment within the hand, which consists in drawing in the thumb and turning the hand farther over to the side at the end of the line. The turning over is shown

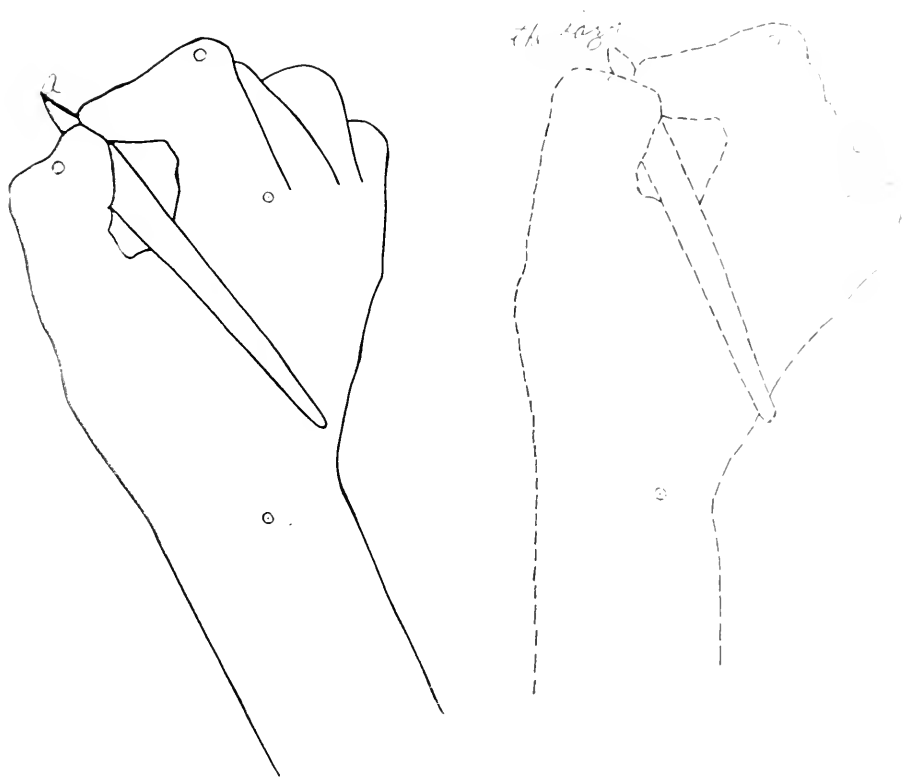


FIG. 25*b*.—Hand position and gross movement of a poor writer from Grade VIII

by the position of the spots on the index finger and the thumb, which are much farther from the margin of the hand at the beginning of the line than at the end. The distinct difference in the quality of the word "brown" and the word "lazy" shows that while the writer has been somewhat successful in the movement along the line at the early part of the line, toward the end the

quick brown fox jumps over the lazy

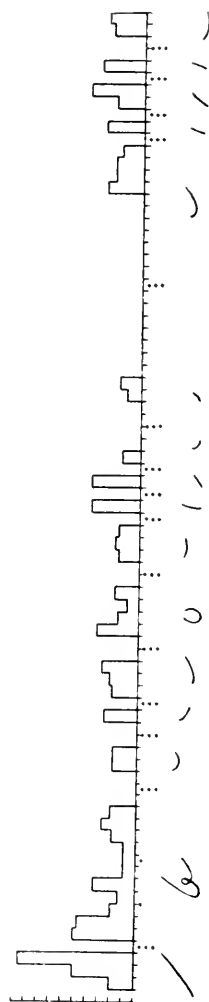


FIG. 26.—Record of a poor writer from Grade VIII

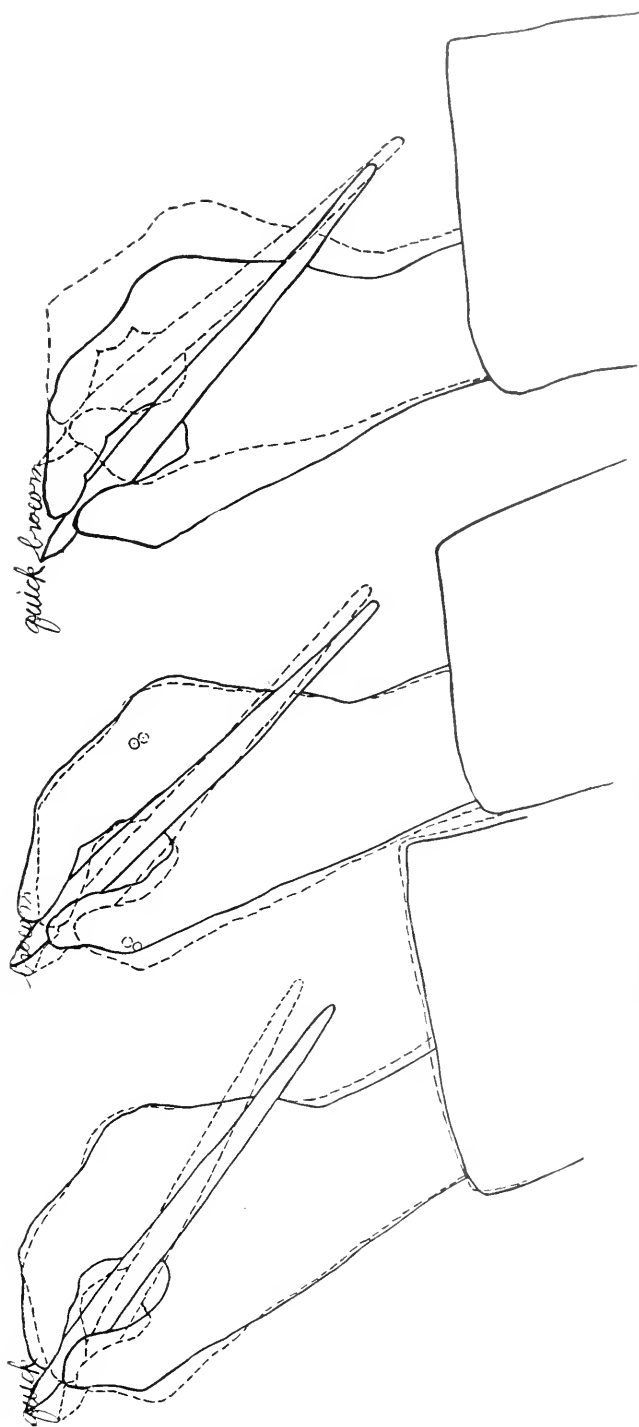


FIG. 27. Hand position and gross movement of a poor writer from Grade IV

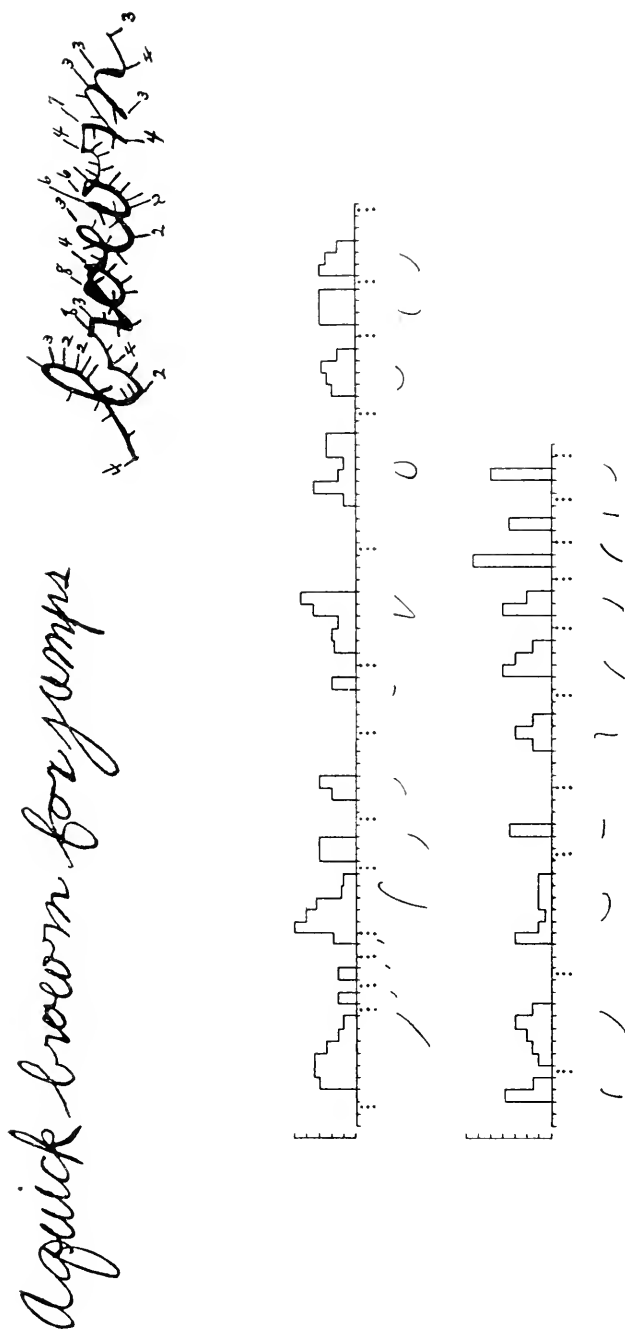


FIG. 28.—Record of a poor writer from Grade IV

movement is decidedly awkward. The strokes of the letters are made with the fingers and the hand, as in the case of most subjects who turn the hand far over toward the right.

The speed curve of the writing of this subject (Fig. 26) shows a distinct variation from the standards that have been set up and

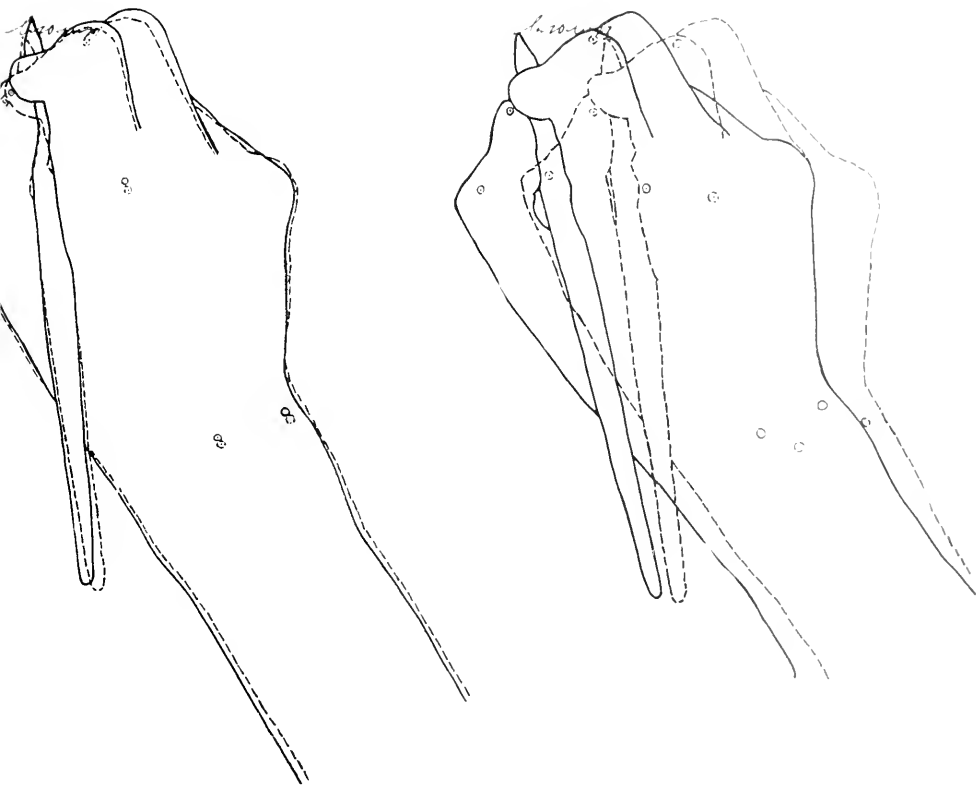


FIG. 29a.—Hand position and gross movement of a poor writer from Grade IV

marked inconsistency within itself. In some parts of the word the movement is divided into units after the manner which has already been described. This may be seen in the case of the *r*, the *w*, and the *n*. At the bottom and the last turn of the *b*, however, where a pause usually occurs, none is found. The same is true of *o*. The connecting stroke between the *r* and the *o*, on the other hand, has a pause in spite of the fact that there is no sharp turn within it.

The excessively long pause in the last turn of the *w* constitutes a distinct break in the movement. The mixture of tall, narrow columns, which indicate sudden rapid movements, and groups of lower columns gives the picture of irregularity in speed. The movement, then, is irregular and is not well adapted to the form of the letters that are to be produced.

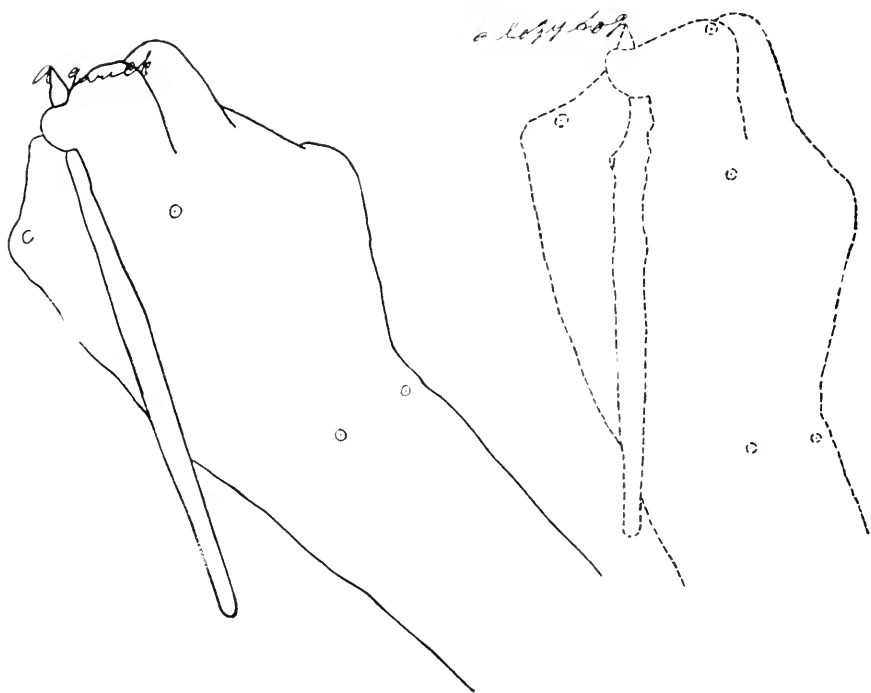


FIG. 29b.—Hand position and gross movement of a poor writer from Grade IV

The next record is that of a poor writer from the fourth grade of the University Elementary School. The hand (Fig. 27) rests upon the side, and, for the most part, the movement along the line is made without ease or fluency. The movement from the beginning to the end of a word is made partly by drawing back the wrist and partly by drawing in the fingers and thumb. The angle of the penholder is changed here, as also in the movement from the beginning to the end of the line. A distinct hitch in the movement occurs between the *w* and the *n*, and this is represented

A quick brown fox jumps
over the lazy dog

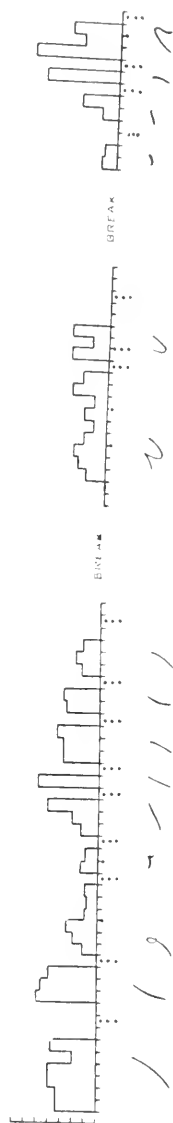


FIG. 39.—Record of a poor writer from Grade IV

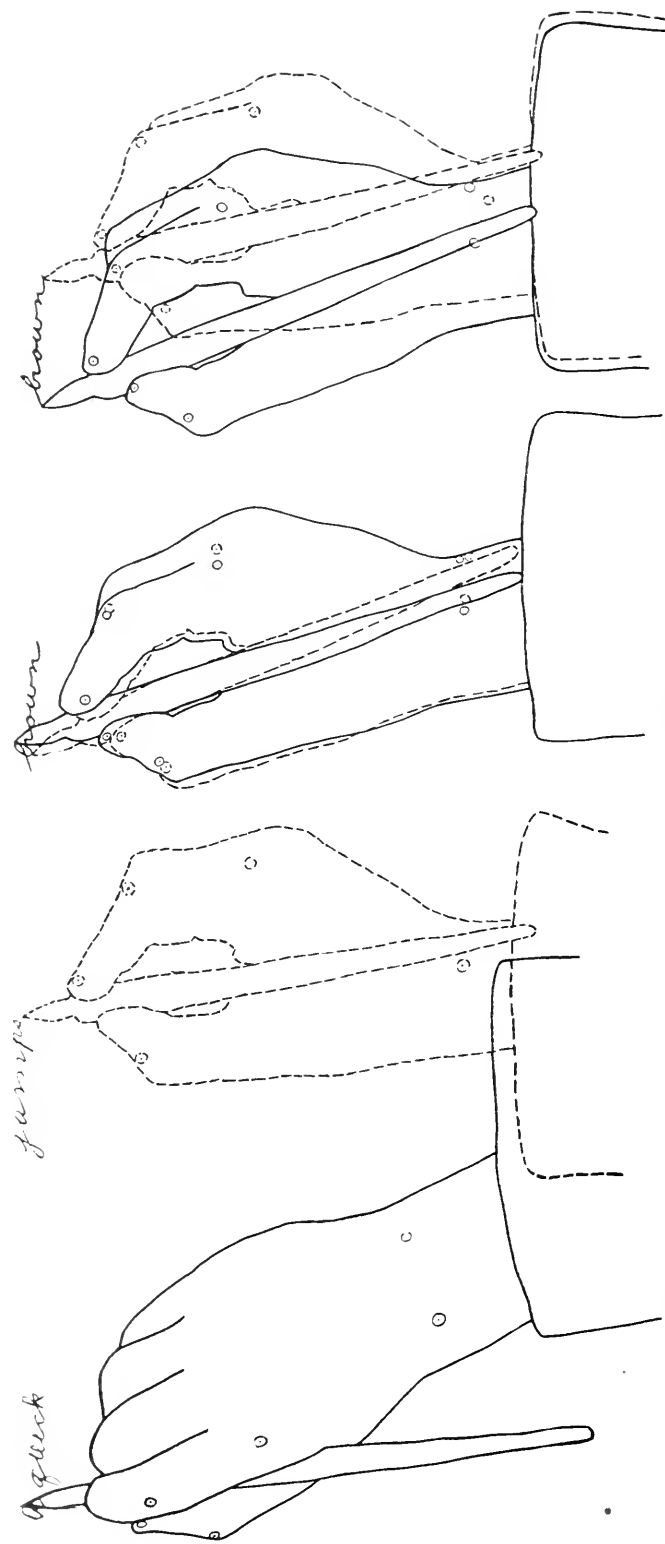


FIG. 31.—Hand position and gross movement of a writer from Grade IV after training. The record before training is shown in Fig. 27

a quick brown fox jumps

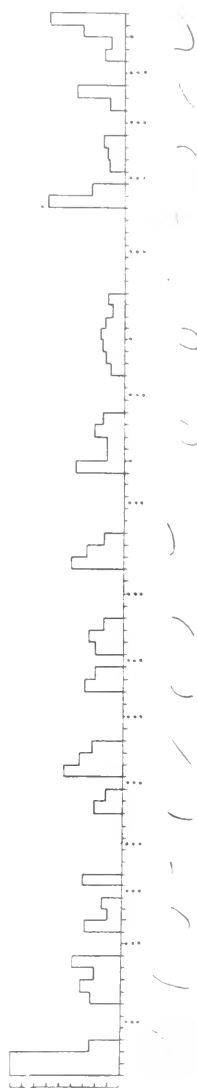


FIG. 15. Record of a writer from Grade IV after training. The record before training is shown in Fig. 14.

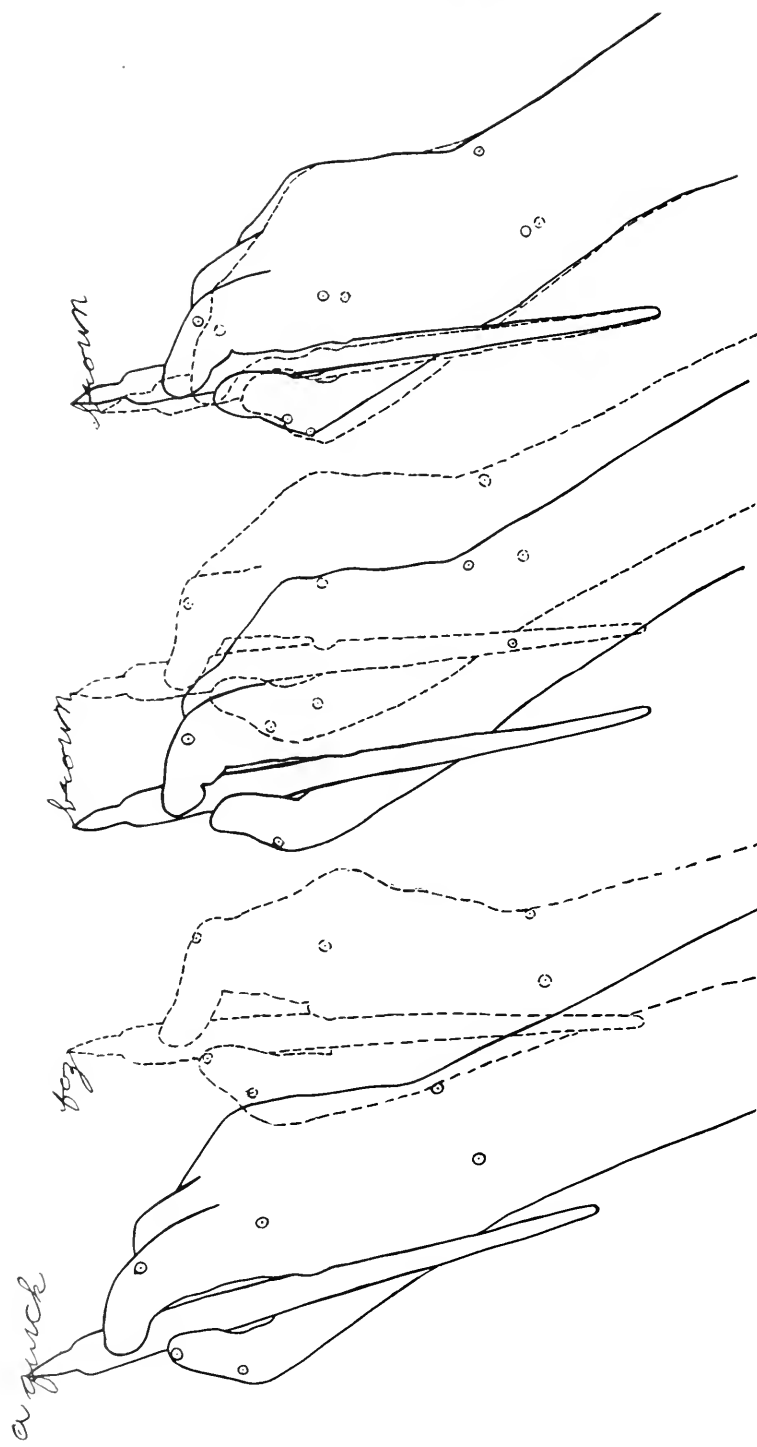


FIG. 33.—Hand position and gross movement of a poor writer from Grade III A before training

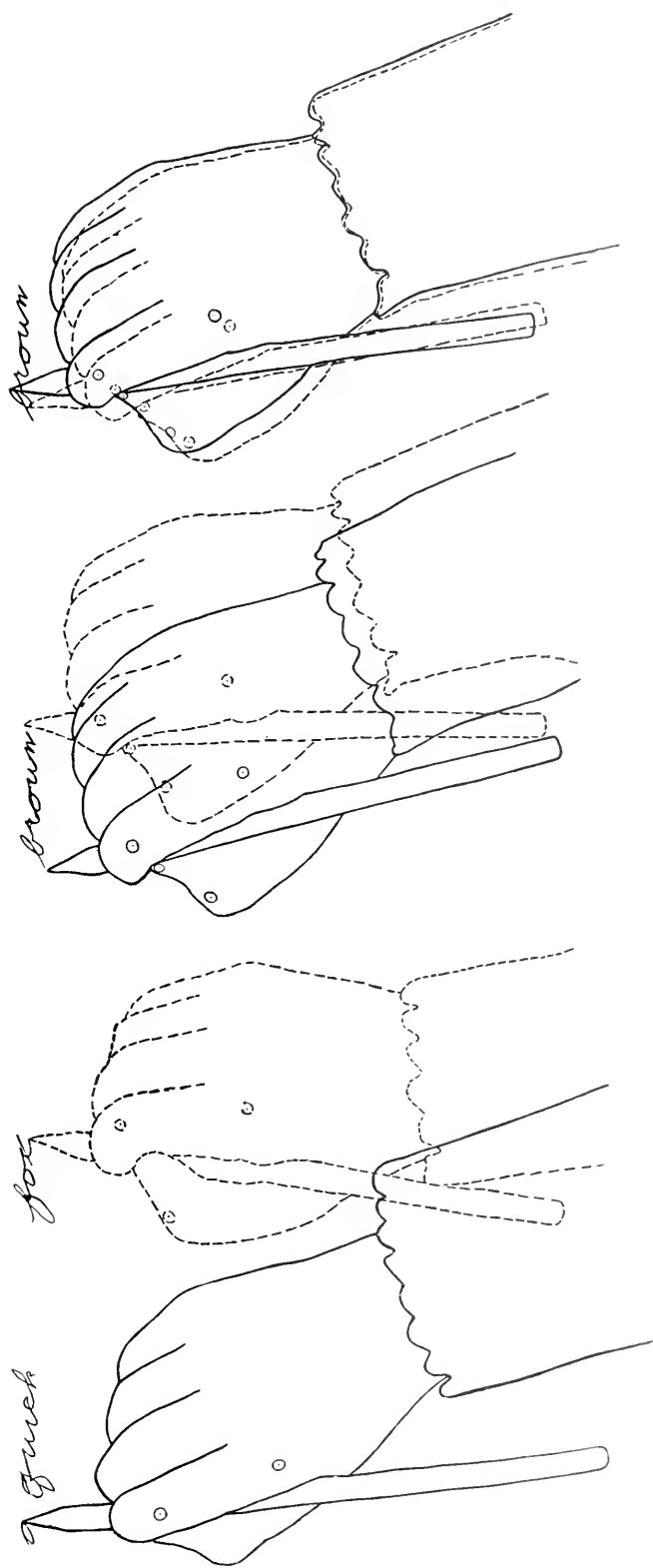


FIG. 34. Hand position and gross movement of a writer from Grade III A after training. The record before training is shown in Fig. 33.

in the speed curve by the pause at this point. The downstrokes are made by means of the fingers and the hand, with the penholder pivoted at the middle.

The speed curve of this writer (Fig. 28) shows marked irregularities. Note, for example, the pauses in the course of the first upward stroke of the *b*. Another example of irregularity is the very rapid movement from the shoulder of the *r* to the top of the *o*. The form is characterized by a sharp turn, instead of the rounded one of the good writer, and it is made without a pause. Note further the marked difference in the speed curves of the *w* and of the *n*. The former is made by a slow movement; the latter by a series of very rapid movements interrupted by pauses. The pause between the *w* and *n*, which is accompanied by a hitch along the line, has already been mentioned.

Figs. 29*a* and 29*b* contain the records of a poor writer from the fourth grade of the Ray School. In this case the hand is held fairly level, but does not slide easily upon the third and fourth fingers. This may be accounted for in part by the fact that the elbow is held so far to the right that the forearm must be drawn back a considerable distance at the end of the line. The hand is also turned over toward the right and is drawn backward somewhat at the wrist. The writing deteriorates toward the end of the line. These facts taken together indicate that the movement of the hand across the page is not skilfully made. The strokes of the letters are made by a movement of the hand accompanied by a backward movement of the arm and by slight finger movement.

There are several evidences of marked inco-ordination in the speed curve of this writer (Fig. 30). One indication of this is the existence of the two complete breaks in the movement after the *o* and the *w* and the partial break after the *b*. These breaks are evidently not simply division points between the units of the movement but indicate irregularities in the movement. The movement on the latter part of the *b* and the movement on the latter part of the *r*, for example, are radically different in speed. Before the break it is relatively slow and even; after the break it is rapid and spasmodic. A similar contrast may be found between the movement on the *w* and the *n*, as indicated by the

speed curve. The pause near the beginning of the first stroke of the *n* is a further evidence of irregularity.

SUMMARY

In contrast with the good writers these poor writers have difficulty in the sideward movement across the page, and this difficulty seems to be due in large measure to the fact that they rest their hands on the side. As another consequence of this position the hand frequently gets into a cramped position at the end of a word or at the end of a line. No clear contrast with the movement of the good writers appears in respect to the relative amount of finger or arm movement in forming the letters. There is a sharp contrast, however, in the type of speed organization. The poor writers do not organize the movement into speed units so clearly as do good writers, and the units of movement do not conform so well to units of form of the letters.

ILLUSTRATIONS OF THE CHANGES IN POSITION AND MOVEMENT AFTER TRAINING

The next four records present the changes which have taken place in the position and movement of two subjects after a short period of training.

The record of the first subject is shown in Figs. 31 and 32. His record before training appeared in Figs. 27 and 28. These records indicate that we have caught this child in the transition period in the formation of a new habit. He starts out bravely at the beginning of the line with his hand held fairly level and resting upon the fingers. At the end of the line, however, the hand is turned over, resting on the side. Evidence that there has been a change is to be found in the manner in which the hand is moved from the beginning to the end of the word "brown." This movement does not consist wholly in drawing back the wrist, as was the case before training, but it is made in part by a sideward movement of the forearm. The change in the direction of the penholder is not radical. The movement upon the letter strokes is not made primarily at the finger joint but is a movement in which the hand contributes. This appears from the fact that there is a slight

movement of the wrist toward the right while the downward stroke of the *b* is being made.

A change in the direction of regularity of movement and its adaptation to the form of the letters may also be seen in the speed curve (Fig. 32). Nothing like the inco-ordination previously shown in the first stroke of the *b* is seen, and there is no marked inconsistency similar to the last stroke of the *r* and the connecting stroke between the *r* and the *o* in the first record. The chief breaks in regularity are found in the rapid strokes at the beginning of the *b* and on the first and last strokes of the *n*. The pauses are in general shorter and more regular. The picture of the speed changes is that of a somewhat better co-ordinated movement after training than before.

In Figs. 33 and 34 are presented the hand positions of a poor writer in Grade III A of the University Elementary School before and after training. At the beginning of the line there is not a very radical change in the position of the hand after training. There is, however, a radical change in the manner in which the hand is carried along the line, as shown by the fact that after training the hand retains substantially the same position that it assumes at the beginning of the line, whereas before training the position at the end of the line is radically different from that at the beginning. This indicates that the sideward movement in writing the line has become better organized. One element in this increased efficiency is that the arm does not have to be drawn back as the line is written, partly on account of the fact that it is held somewhat more perpendicular to the line of writing.

The movement during the writing of a word before training is not accurately represented by the drawing. On its face the drawing seems to indicate that the arm as a whole moves forward during the writing of the letters. This appearance is caused by the fact that the arm was lifted and shifted in position at a particular point in the word. The movement, then, is not a continuous one. This will be brought out in more detail in a moment by another method of presentation. The downward strokes of the letters are made in both cases with the arm, accompanied by a

slight amount of finger movement. There has been no radical change in this phase of the writing as a result of training.

A more radical change than that in position and movement has been brought about in the speed curve (Figs. 35 and 36). There are very marked evidences of inco-ordination in the curve of the writing before training. Note, for example, the very long and irregularly placed pauses. Note further the pauses which occur in the middle of the upstroke and the downstroke of the *b* and on the upstroke of the *o*, the connecting strokes between the *o* and the *w*, between the *w* and the *n*, and the two middle strokes of the *n*. The strokes of the letters are not made by continuous movements but by movements which are interrupted irregularly by pauses. Furthermore, the movements themselves are not uniform in character. In some cases they are abrupt and rapid, as represented on the speed curve by tall, narrow columns, and in other places they are made slowly and gradually. The speed curve gives us much the same picture as is presented by the form of the word itself. After the training there are no such evidences of marked inco-ordination. There are rather long pauses, but they come with a fair degree of regularity and the movements between them are of much the same character throughout the word. Each stroke is made with smoothness and rapidity. There is failure at one point to make the movement correspond to the ideal form of the letters, namely, in the last part of the *w*, where there is no pause. But in spite of this there is a vast improvement as a result of the short period of training.

Figs. 37 to 43 present in a more detailed manner the type of movement from the beginning to the end of a word of three poor writers and two good writers. In addition the change which has taken place in two of the poor writers during training is indicated. It will be remembered that the speed curve which is shown in Fig. 30 indicates several breaks in the writing of the words. These breaks are represented in more detail in Fig. 37 by the positions of certain reference points upon the hand at the successive exposures of the camera. The positions of each of these reference points, namely, the end of the thumb, the end of the fingers, the joint of the thumb, knuckle, two dots on the wrist, and the end of the pen

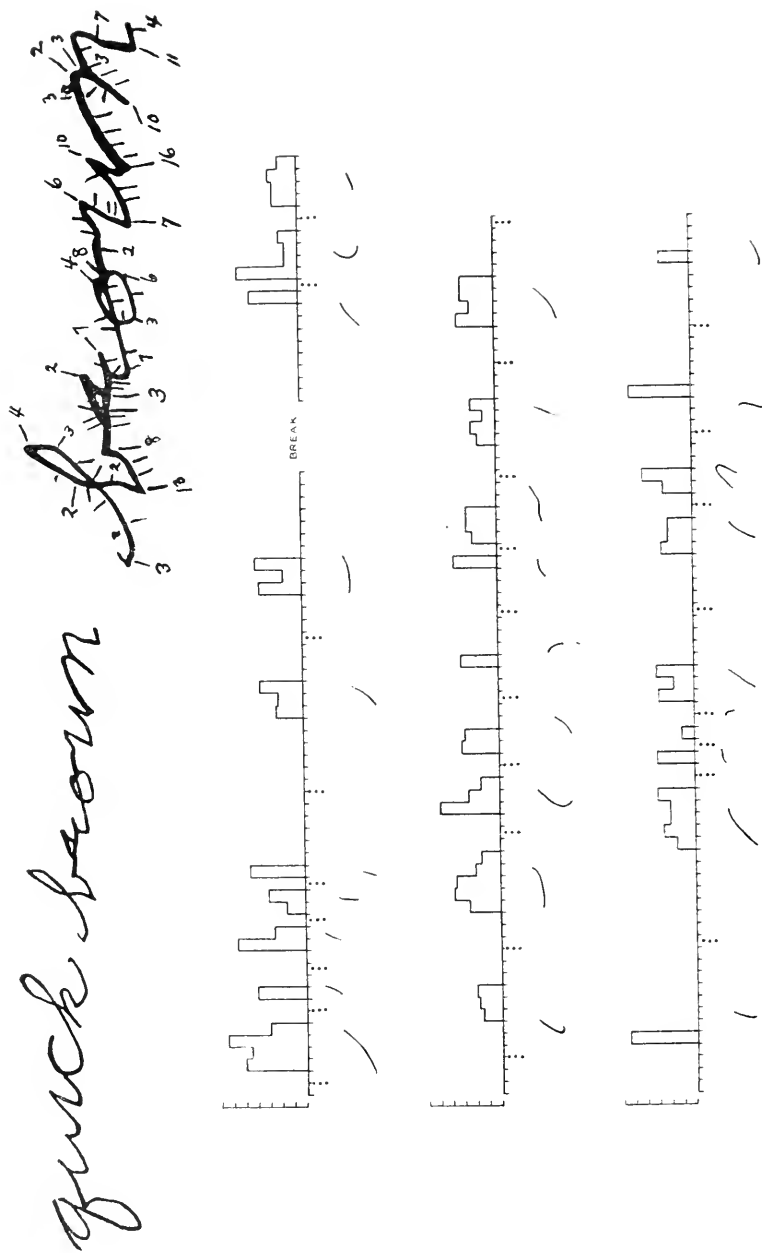


FIG. 35.—Record of a poor writer from Grade III A before training

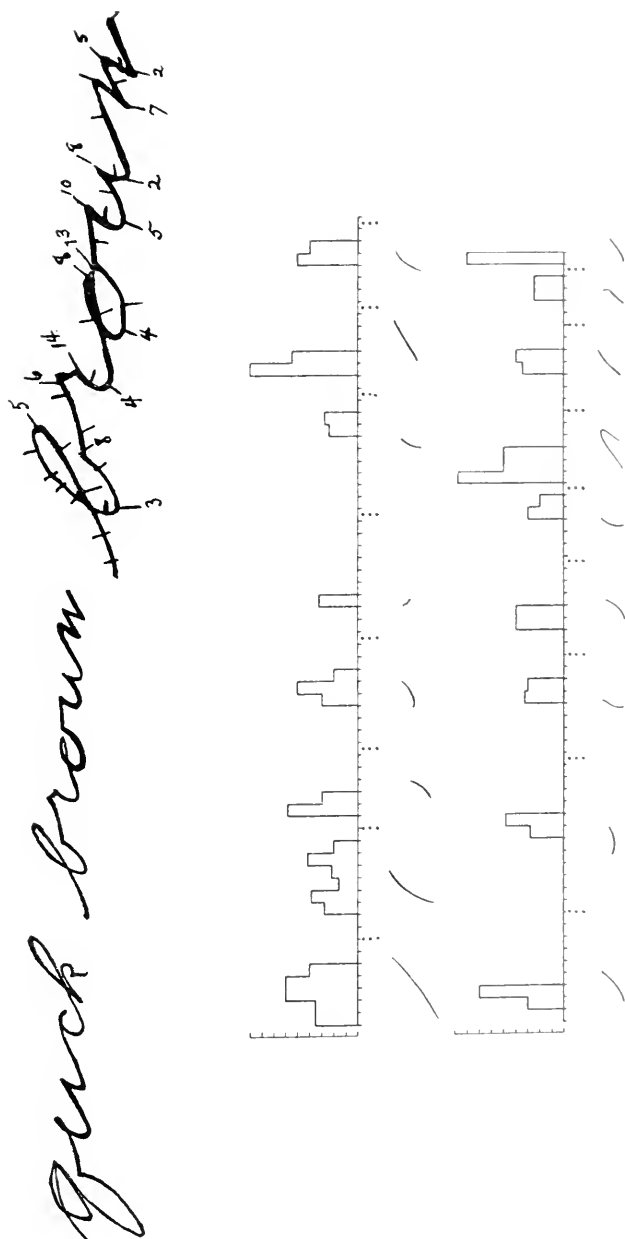


FIG. 36. Record of a writer from Grade III A after training. The record before training is shown in Fig. 3.

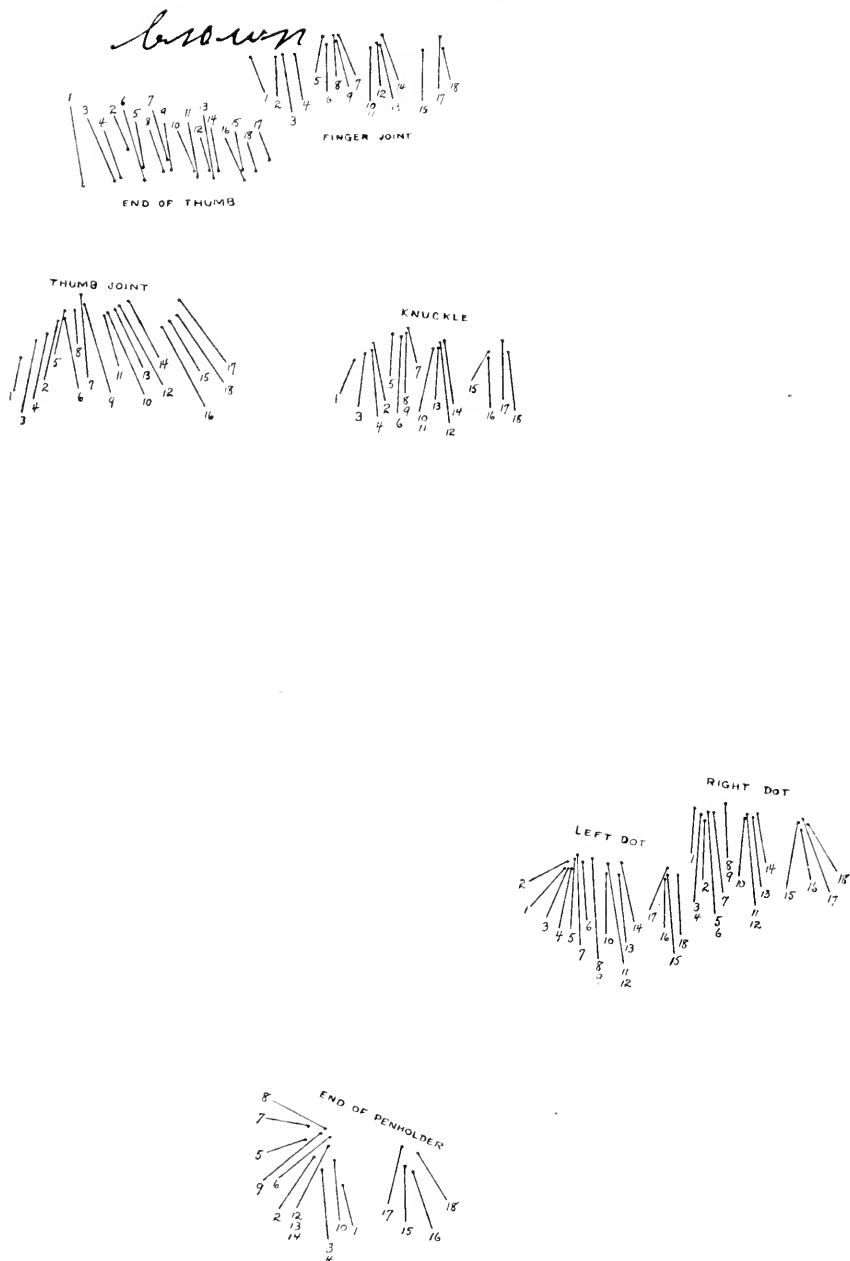


FIG. 37.—Detailed record of the progression of the hand of a poor writer from Grade IV. The speed curve of this writer is shown in Fig. 30.

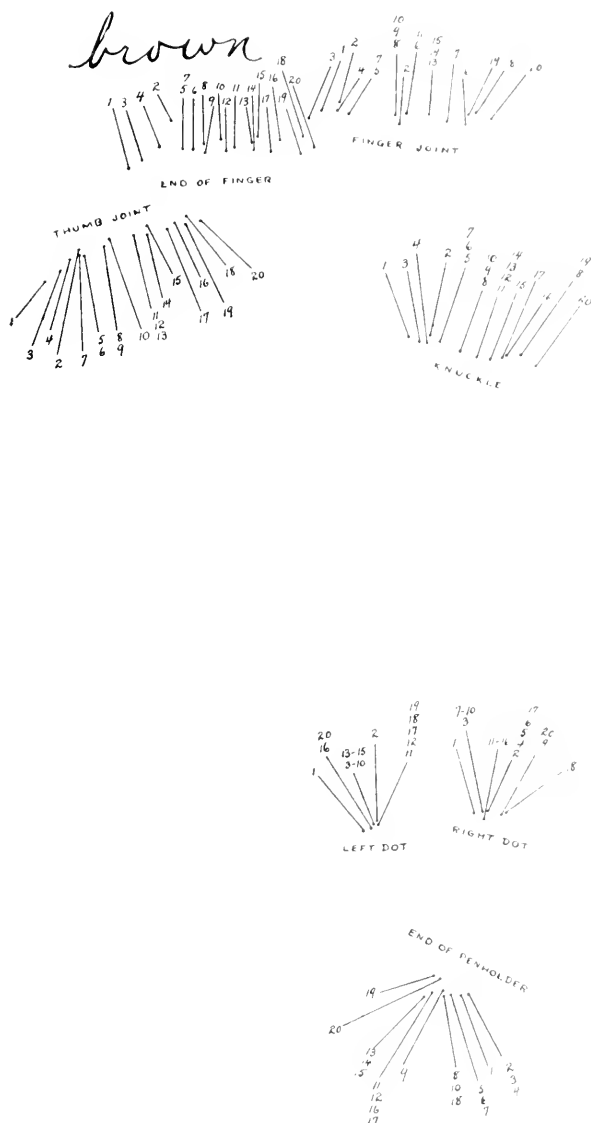


FIG. 38.—Detailed record of the progression of the hand of a good writer from Grade IV.

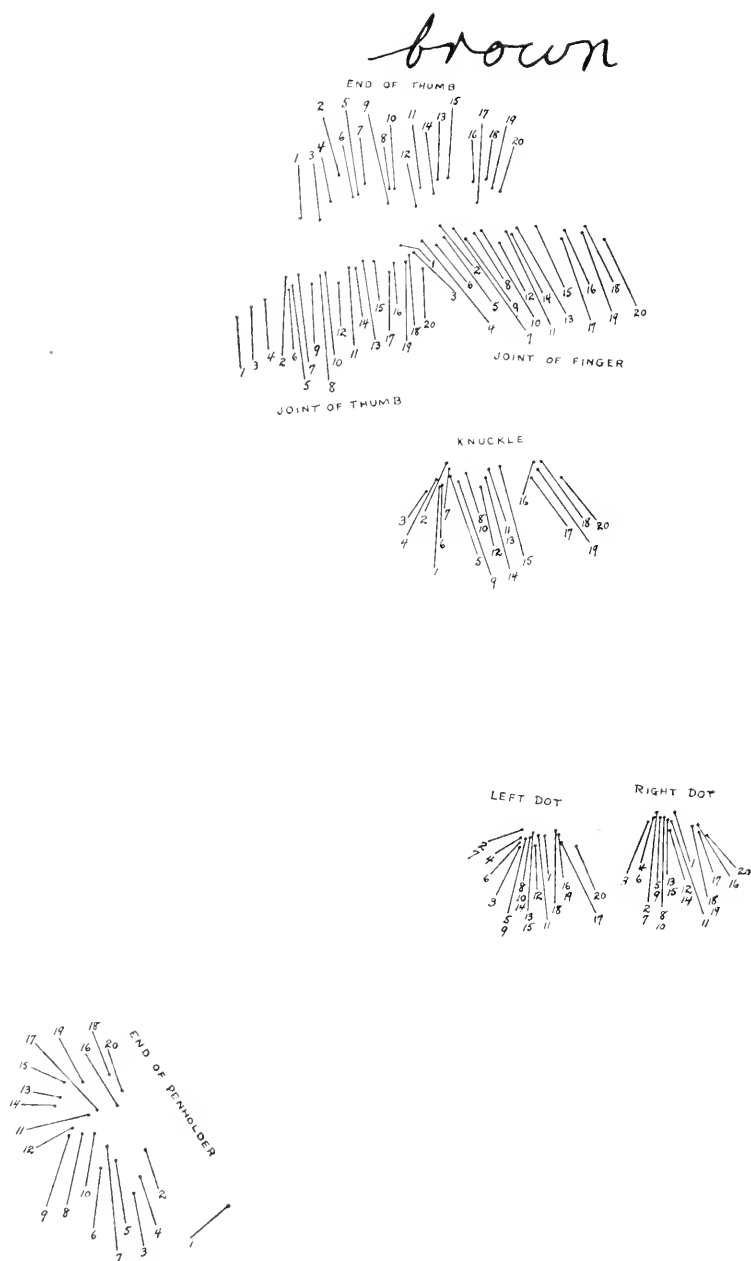


FIG. 39.—Detailed record of the progression of the hand of a good writer from Grade IV.



FIG. 40.—Detailed record of the progression of the hand of a poor writer from Grade IV before training. The record of this pupil after training is shown in Fig. 41. The speed curves of this subject are shown in Figs. 28 and 32.

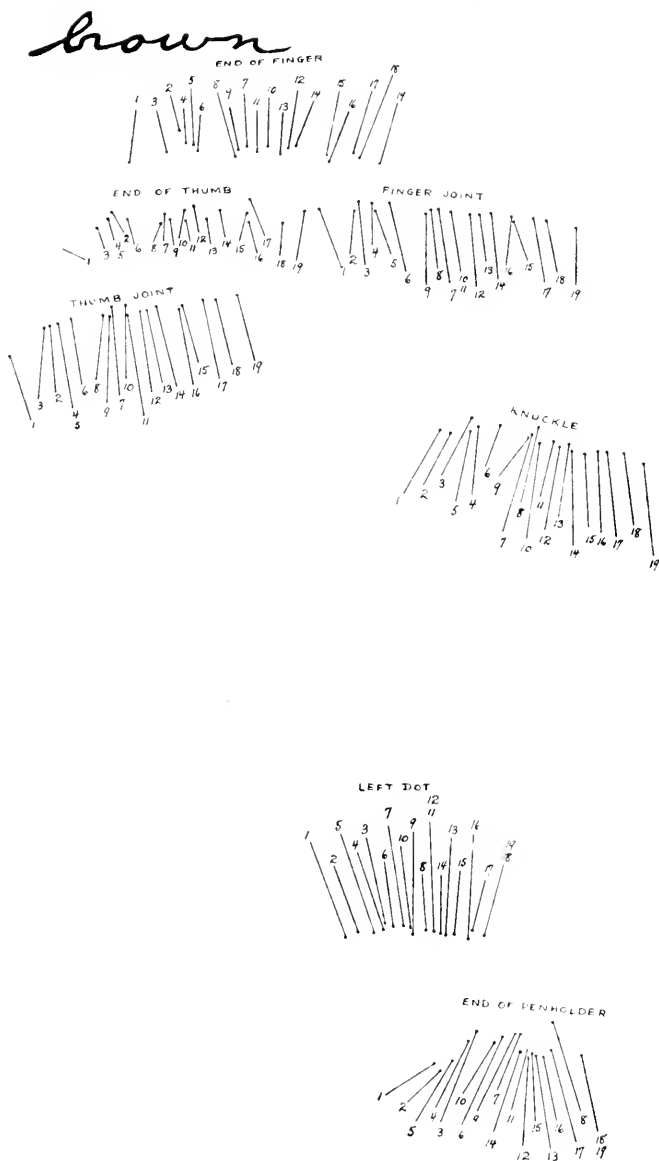


FIG. 41.—Detailed record of the progression of the hand of a writer from Grade IV after training. The record of this pupil before training is shown in Fig. 40.

brown

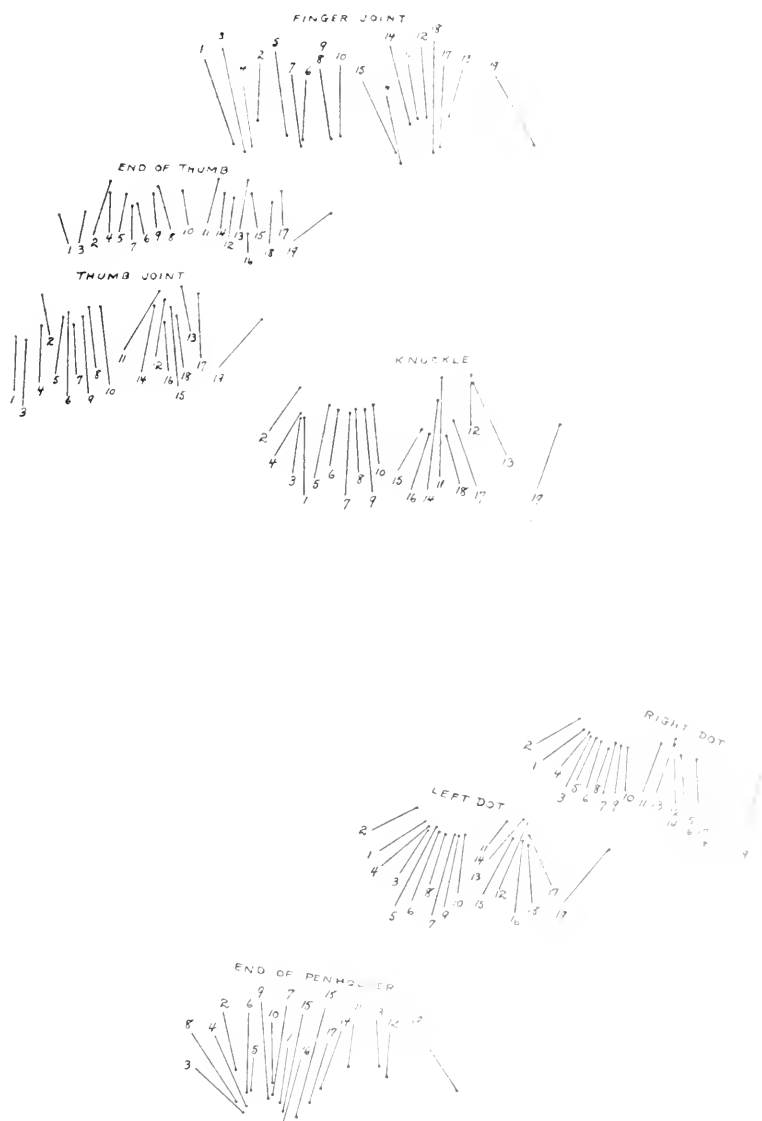


FIG. 42.—Detailed record of the progression of the hand of a poor writer from Grade III A before training. The record of this pupil after training is shown in Fig. 43. The speed curves of this pupil's writing are shown in Figs. 35 and 36.

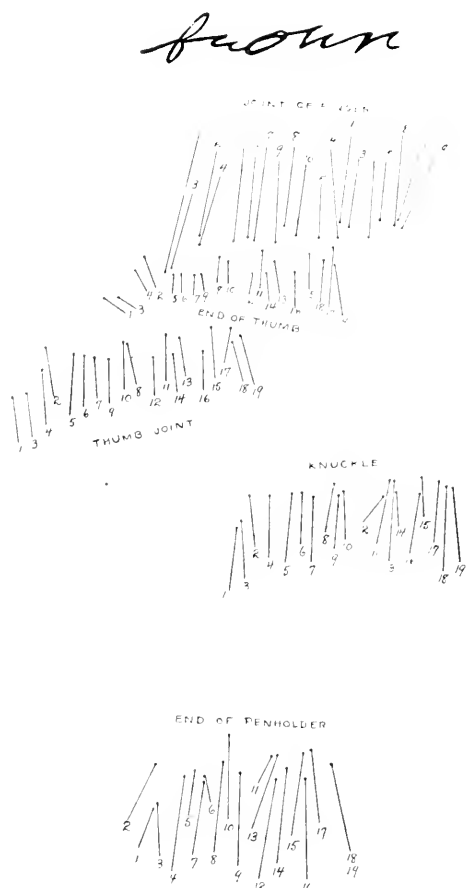


FIG. 43.—Detailed record of the progression of the hand of a pupil of Grade III A after training. The record of this pupil before training is shown in Fig. 42.

are indicated by dots which are given serial numbers. The movements of these dots or reference points while the word is being written indicate the nature of the movement of the hand. Slight shifts in the movement of the hand throughout the word are indicated by the positions of the reference points on the thumb, fingers, and knuckles. A larger readjustment toward the end of the word is indicated by the separation of a group of dots. There is here evidently a movement which may be described as hitching along the line toward the end of the writing of the word. The positions in exposures 15 to 18 are separated into a group from those which precede them.

This type of movement may be contrasted with that of a good writer in the same grade (shown in Fig. 38). The hand is carried from the beginning to the end of the word by this subject by a movement of the wrist. This may not be regarded as the best possible movement, but at any rate there is no hitching of the hand, and the manner of progress of the hand as indicated by the dots on the thumb and the fingers is highly regular. As a consequence of the fact that the movement is made largely with the wrist, the end of the pen moves slightly to the left during the writing of the word. This movement, however, is one of regular progression. We have here, then, in contrast to the record from the preceding subject, a smooth, regular progression of the hand along the line.

In Fig. 39 is shown the record of another good writer, although not so good as the preceding one. Here, also, the dots on the wrist remain close together, indicating that the translation of the hand has been largely effected by a movement at the wrist joint. There is no evidence of a marked readjustment of position at any one point during the writing of the word. The movements of the knuckles and the joints of the fingers, while not so regular as in the case of the subject shown in Fig. 38, are still more regular than in the record shown in Fig. 37. The end of the pen moves in a circular direction toward the left.

The next two records (shown in Figs. 40 and 41) represent the same subject before and after training. Although the period of training was brief, there is evident a noticeable change in the type of movement. Before training there is a hitching movement

during the writing of the word, as indicated by the separation of the dots (16 to 19) at the end of the pen, the wrist, and the knuckles. After training the wrist moves more steadily along the line, and the points on the knuckles indicate a more regular progression. There is still a hint of a readjustment after point 6, but the picture in general is one of greater regularity.

A still more pronounced improvement is evident in the records of the next subject (shown in Figs. 42 and 43). Before training the subject shows a lack of co-ordination in the latter part of the movement along the word. There is not only a readjustment, which takes place at exposure 11, but the rest of the word is marked by noticeable irregularity. The movement of the end of the pen, which goes backward and forward over a wide area, and the movement of the points on the wrist, the knuckles, the finger joints, and ends of the fingers all indicate a marked lack of uniformity. After training there is no such irregularity, at least to such a marked degree. There is a slight readjustment represented at the eleventh exposure, but there is a very good semblance of a regular progression to the right in the various parts of the hand from that point forward.

SUMMARY OF THE ANALYSIS OF ILLUSTRATIVE CASES

If we may make a preliminary generalization on the basis of the few cases which have been discussed we may say that while there is considerable variety in the hand positions which are assumed, and while the good and the poor writers are not, in most cases, very clearly marked off by hand position, yet this one point seems to emerge as of distinguishing importance: The manner in which the hand moves across the line carrying the pen from one letter to another constitutes a rather marked characteristic difference between good and poor writers. There are certain positions which render sideward movement possible and easy, and there are other positions which render it impossible, or at least difficult. We can make a generalization somewhat more valid by the later appeal to a larger number of cases, and can discuss in greater detail the varieties of position and movement.

Aside from the hand movement and position, the organization of the total movement with respect to the speed changes appears to be of great importance. We have attempted to indicate how the good writer

adjusts the changes in speed to the character of the form which he wishes to produce. In addition to this there appear to be certain general characteristics of a well co-ordinated movement which are in a measure lacking in a poorly co-ordinated movement. There is a certain regularity and smoothness of movement, which is represented, for one thing, by a similarity in speed in the strokes which are similar in character and by a lack of suddenness and abruptness in the transition from slow to rapid movement.

The elements of a good writing co-ordination, as determined by a study of the foregoing records and others which cannot be presented, include the following items:

1. The organization of the movement into units.
2. The arrangement of the division points between units to correspond to the forms to be produced.
3. The execution of each unit in a well co-ordinated manner:
 - a) With the greatest speed, in general, in the middle of the stroke.
 - b) With a correspondence between the speed of the movement and the length and simplicity of the stroke.
4. Consistency or the production of the successive strokes with similar speed changes. (Allowance must be made for variations due to differences in the form of successive letters.)

CHAPTER IV

STATISTICAL COMPARISON OF THE TYPES OF POSITION AND MOVEMENT OF GOOD AND POOR WRITERS

HAND POSITION

The foregoing inspection of typical cases gives the impression that some features of hand position and movement and some types of speed changes are favorable to good writing while others are unfavorable. This inspection is supplemented by the following statistical tables in order to give the comparisons an objective numerical character and to avoid the possible error which may arise from the selection of a few cases for study. The comparison was made by the following method. For each feature of the position which seems worth while to study certain descriptions are laid down to distinguish the groups into which the writers can be classified. The nature of these classes will be clear from Table I.

Each individual is classified according to each item of position, and the classifications are entered in a table along with those of the other subjects of the same group. In some cases a subject is entered in two or more classes because his position varied in different parts of the writing. After these tables were completed the number and percentage of cases in which each position occurred were calculated for each group of subjects, and the results from the different groups were then compared.

HAND POSITION OF CHILDREN

Table II presents the summary of the results from the children. This table is to be read as follows. Among the poor writers of the University Elementary School two cases of the first position with respect to pronation (with wrist nearly level) were observed. These constituted 8 per cent of the cases in this group of children. Eight cases, constituting 29 per cent, of the first position in hand support (upon the fingers) were observed.

The first outstanding fact to be observed in Table II is that there is a wide variation in position both among good and among poor writers. Some good and some poor writers are to be found who employ every position which is found to exist at all. Nor are

TABLE I

BASIS OF CLASSIFICATION OF THE INDIVIDUALS ACCORDING TO THEIR
HAND POSITION

A. Degree of pronation	$\left\{ \begin{array}{l} 1. \text{ Wrist level, or tilted less than } 10^\circ \\ 2. \text{ Wrist tilted } 10^\circ \text{ to } 45^\circ \\ 3. \text{ Wrist tilted } 45^\circ \text{ or more} \end{array} \right.$
B. Support of the hand	$\left\{ \begin{array}{l} 1. \text{ On the third and fourth fingers} \\ 2. \text{ On the side of the hand} \\ 3. \text{ On the base of the hand} \end{array} \right.$
C. Angle of the arm with the base line of the writing	$\left\{ \begin{array}{l} 1. \text{ Nearly perpendicular} \\ 2. \text{ } 10^\circ \text{ to } 30^\circ \text{ from the perpendicular to the right} \\ 3. \text{ } 30^\circ \text{ to } 60^\circ \text{ from the perpendicular to the right} \\ 4. \text{ To the left of the perpendicular} \end{array} \right.$
D. Angle of the penholder with direction of down-strokes	$\left\{ \begin{array}{l} 1. \text{ Less than } 10^\circ \\ 2. \text{ } 10^\circ \text{ to } 30^\circ \\ 3. \text{ } 30^\circ \text{ to } 60^\circ \\ 4. \text{ } 60^\circ \text{ to } 90^\circ \end{array} \right.$
E. Angle of penholder with arm	$\left\{ \begin{array}{l} 1. \text{ Nearly } 0 \\ 2. \text{ } 10^\circ \text{ to } 30^\circ \text{ to the right} \\ 3. \text{ } 10^\circ \text{ to } 30^\circ \text{ to the left} \\ 4. \text{ } 30^\circ \text{ to } 60^\circ \text{ to the right} \\ 5. \text{ } 60^\circ \text{ to } 90^\circ \text{ to the right} \end{array} \right.$
F. Relation of finger and thumb on penholder	$\left\{ \begin{array}{l} 1. \text{ Finger below thumb} \\ 2. \text{ Finger opposite thumb} \\ 3. \text{ Finger above thumb} \end{array} \right.$
G. Looseness of grasp of penholder	$\left\{ \begin{array}{l} 1. \text{ Loose} \\ 2. \text{ Medium} \\ 3. \text{ Tight} \end{array} \right.$

these cases extreme or exceptional. In general, the differences between groups of good and poor writers are small compared with differences within each group. The differences which are produced by training are rather marked.

Before proceeding to an analysis in detail of the differences in position we may pause to consider the significance of their smallness. There are several possible explanations. The one which

TABLE II
COMPARISON OF THE FREQUENCY OF VARIOUS HAND POSITIONS AMONG SEVERAL GROUPS OF CHILDREN

GROUP	POST- TION	PRONATION		HAND SUPPORT		ANGLE OF ARM TO BASE LINE		ANGLE OF PEN- HOLDER TO DOWNSTROKES		ANGLE OF PEN- HOLDER TO HOLDER TO ARM		RELATIVE POSI- TION OF THUMB AND FOREFINGER		LOOSENESS OF GRASP	
		A		B		C		D		E		F		G	
		No.	Per- centage	No.	Per- centage	No.	Per- centage	No.	Per- centage	No.	Per- centage	No.	Per- centage	No.	Per- centage
Univ. Elem. School: Poor writers (entire group)	1....	2	8	8	20	5	17	3	11	11	41	10	45	4	18
	2....	10	38	20	71	20	60	7	25	6	22	9	41	8	36
	3....	14	54			2	7	10	30	5	19	3	14	10	45
	4....					2	7	8	29	5	19				
	5....														
Univ. Elem. School: Poor writers who took training	1....	1	6	5	28	1	6	1	6	7	37	8	57	2	14
	2....	9	50	13	72	14	82	5	28	4	21	4	20	5	30
	3....	8	44			2	12	7	30	5	26	2	14	7	50
	4....							5	28	3	16				
	5....														
Univ. Elem. School: Good writers	1....	2	17	7	47	6	38			2	14	9	82	7	64
	2....	4	33	8	53	6	38	5	36	4	29	2	18	3	27
	3....	6	50			2	13	5	36	5	36			1	9
	4....					2	13	4	29	1	7				
	5....									2	14				
Univ. Elem. School: Poor writers after training	1....	12	60	12	71	7	33	7	41	6	30	13	93	8	57
	2....	6	30	5	29	13	62	7	41	2	10	1	7	6	43
	3....	2	10			1	5	2	12	12	60				
	4....							1	6						
	5....														
Ray School: Poor writers	1....	1	8	5	42	2	17	1	13	2	20	7	88	4	50
	2....	8	67	7	58	6	50	5	63	4	40			3	38
	3....	3	25			2	17	2	25	3	30	1	13	1	13
	4....					2	17			1	10				
	5....														
Ray School: Good writers	1....	4	33	8	80	5	42	4	31	4	40	8	100	4	50
	2....	7	58	2	20	7	58	2	15	1	10			4	50
	3....	1	8					4	31	2	20				
	4....							3	23	2	20				
	5....									1	10				

most readily comes to mind is that differences in position are simply expressions of individuality in behavior, or accidental variations, which have no significance at all for skill in writing. This conclusion is valid only where the differences are so small or irregular as to be ascribed to chance. If they are large enough and regular enough, on the other hand, to make it probable that they will be found wherever good and poor writers are compared, then they are of significance, even though their significance be slight.

Where a clear difference between the positions of good and poor writers exists, as it does in a number of instances, why is it not more pronounced? Evidently because there are other causes than hand position which affect the writing. We have already found in the previous inspection that among these further factors are the kind of movement and the nature of speed changes. In addition, the disposition and ability to perceive forms accurately and to exercise care in their production undoubtedly influence neatness and accuracy of writing. It is possible, then, to adopt a hand position which is not the most advantageous and still write fairly well, because certain other requirements are met. On the other hand, it is possible to adopt the hand position which general experience indicates to be favorable and still write poorly, because the movement is not well organized or the writing is not done carefully.

Another possible reason for the lack of sharp distinction between the hand positions of good and poor writers is that the degree of difference between the two groups is not extreme. If the good writers had been nearly perfect writers it may be that we should have found them to use a more nearly uniform type of hand position. But the problem of training elementary-school children in writing is not the same as the problem of training professional penmen. The distinction between the problems is frequently not clearly recognized. The consequence is that a too rigid adherence to what is regarded as the best method, which may be suitable when a very high degree of skill is desired, is frequently attempted in teaching school children. The attempt in large measure fails, and much of the effort is wasted. The excess effort might be saved if less exacting requirements were made.

The question as to which elements of hand position are the most important, and the range of variability which it is probably wise to allow, leads us to a more detailed examination of Table II.

We shall make the following comparisons with reference to each type of hand position: between the good and poor writers in the University Elementary School and in the Ray School; between corresponding classes of writers in the two schools; and between the poor writers in the University Elementary School before and after training.

A. *Degree of pronation or levelness of wrist.*—A level wrist is but little more common among the good writers in the University Elementary School than among the poor writers, particularly when we combine into one group all whose wrists were tilted more than 45° . In the Ray School, however, where presumably emphasis is laid upon this feature, the good writers exhibit it in greater proportion than do the poor writers. The effect of training appears also in the fact that both classes in the public school hold their wrists more nearly level than do the pupils in the University Elementary School. Furthermore, special training caused a marked increase in levelness in the University Elementary School group.

Conclusion.—A wrist tilted not more than 45° from the horizontal, while not essential to good writing and not insuring good writing, is a position which good writers take somewhat more readily under training than poor ones. Its relation to training is clearer than its relation to skill independent of training. This evidence by itself does not indicate that great stress should be laid upon this feature.

B. *Support of the hand.*—There is a greater difference between the good and poor groups in both schools in this characteristic than in the levelness of wrist, the support of the hand on the fingers being preferable to the support on the side of the hand. This element also is very susceptible to training, which affects writers of native skill more than those not so well endowed.

Conclusion.—The indications are that the support of the hand by the third and fourth fingers instead of on the side of the hand is distinctly preferable.

C. *Angle of the arm with the line of writing.*—In this feature we have a characteristic which is evidently not affected by the training in the Ray School as compared with that in the University Elementary School. We have therefore an opportunity to observe its relation to good writing uncomplicated by differences in training. In both schools the better writers more commonly than the poor ones write with their arms approximately at right angles to the line of writing. In the latter group a position in which the elbow is shifted to the right, reducing the angle on the right-hand side, predominates. Attention was given to this feature in the training class of the University Elementary School, with the result that the perpendicular position of the arm became more common.

Conclusion.—A position of the forearm at right angles to the line of writing is the preferred one.

D. *Angle of the penholder with the downstrokes of the letters.* This feature and the next one, the angle of the penholder with the arm, are concerned with the finer details of hand position. The direction of the penholder is influenced by the degree of pronation (levelness of the wrist) and by the position of the arm, but it is also influenced by the finer adjustments of the fingers independently of the gross position of the hand. The angle of the penholder with the downstrokes is related to the angle which it makes with the arm, but the two are not identical. While these two features, then, are related to each other and to others which have already been described they are to some extent independent and deserve separate treatment.

The older orthodox position of the penholder is one in which it points toward the right ear or shoulder. This means that it should point to the left of the forearm and approximately in the direction of the downstrokes. This requirement is commonly relaxed in modern systems, but it is still considered desirable that the penholder should point somewhat to the left of the forearm, which would bring it ordinarily nearly in the direction of the downstrokes.

From the results of our study no clear relation is manifest between good writing and the angle of the penholder to downstrokes. The distribution of good and poor writers in the University Elementary School is very much the same, except that 11 per cent of

the poor writers hold the penholder more nearly in the direction of the downstroke than any of the good writers. In the Ray School a larger percentage of the good writers than of the poor writers hold the pen in this position, but a larger percentage of good writers hold the pen at a considerable angle to the downstrokes also. On the other hand, this feature of the position seems to be considerably influenced by training, which, in the cases before us, causes the penholder to point more nearly in the direction of the downstrokes than it otherwise would.

Conclusion.—The evidence indicates that a small angle between the penholder and the downstrokes is more largely an artificial product of training than a factor in good writing and does not merit especial emphasis.

E. Angle of penholder with arm.—The significance of the angle of the penholder with the arm is ambiguous, as is its angle to the letter strokes. In the University Elementary School a larger percentage of good writers than of poor writers hold the pen to the left of the forearm, but among the Ray School children the preferred position is in a line with the forearm. The effects of training also are not uniform.

Conclusion.—Our results do not point to any position of the penholder as being decidedly better than the others.

F. Relative position of finger and thumb on the penholder.—It will be remembered that in commenting upon the hand position of one of the poor writers it was noted that the forefinger was situated opposite the thumb in the grasp of the penholder. The statistics with reference to this feature of the grasp of the penholder have been collected in column F of Table II. It appears from an inspection of this table that it is possible to train pupils so that they will uniformly place the finger below the thumb, which is the natural position on account of the greater length of the finger than of the thumb. When children are not particularly trained to take this position, however, there is a disposition to draw the finger upward and to place it either opposite to the thumb or above it. In the case of such pupils a large number take one or the other of these positions. There is a distinct difference, however, between the good writers and the poor writers in this respect. Most

of the good writers place the finger in the more natural position, that is, below the thumb. The result of the training has been to make this position almost universal.

Conclusion.—It is much more advantageous to grasp the penholder in such a way that the finger rests upon it below the thumb, and this position is readily susceptible to training.

G. Looseness of grasp of penholder.—In column G of Table II another characteristic is represented which is not susceptible of such exact definition and classification as is the relationship between the finger and the thumb. The looseness of grasp of the penholder can be judged only to an approximate degree. It is possible, however, by the observation of a writer or of the motion-picture records to judge roughly whether the penholder is grasped tightly or loosely. There appears in this respect also to be a marked difference between the grasp of good writers and that of poor writers. There is also a distinct difference in the grasp of the poor writers before and after training. After training none of them grasp the penholder tightly, while before half of them did so. In the public schools the training has evidently almost eliminated the tight grasp of the pen.

Conclusion.—It is much more advantageous to grasp the penholder with a reasonable degree of lightness than to grasp it tightly, and it is possible with a moderate amount of training to produce the light grasp of the pen.

HAND POSITION OF ADULTS

We have seen that the interpretation of facts which we discover in the study of children's writing is complicated by the effects of differences in training. For the purpose of discovering what differences between good and poor writers are to be found when the results of school training have been overlaid with the habits built up in later practice, seventeen adults were studied. Nine of these were classified as poor writers and eight as good writers, although the contrast between the two groups is not always sharp. A summary of the hand positions which are characteristic of the two groups is given in Table III, which is constructed in the same manner as Table II.

As in Table II, the total number of cases does not always agree with the number of individuals, because the same individual sometimes employed more than one position. In a few cases, among adults, the records were defective and the cases could not be recorded. The statistical comparisons, for this reason as well as on account of the small number of cases, must be interpreted broadly.

TABLE III

COMPARISON OF THE FREQUENCY OF THE VARIOUS HAND POSITIONS AMONG TWO GROUPS OF ADULTS

GROUP	POSITION	PRONATION		HAND SUPPORT		ANGLE OF ARM TO BASE LINE		ANGLE OF PENHOLDER TO DOWN-STROKES		ANGLE OF PENHOLDER TO ARM	
		A		B		C		D		E	
		No.	Per-cent-age	No.	Per-cent-age	No.	Per-cent-age	No.	Per-cent-age	No.	Per-cent-age
Poor writers.....	1.....	2	22	4	44	5	63	.....	.....	2	25
	2.....	2	22	5	50	.....	.....	.....	.....	2	25
	3.....	5	50	.....	.....	.....	.....	7	88	1	13
	4.....	.....	.....	.....	.....	3	38	1	13	3	38
	5.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Good writers.....	1.....	4	50	7	100	6	75	.....	.....	2	25
	2.....	3	38	.....	.....	.....	.....	1	13	1	13
	3.....	1	13	.....	.....	2	25	6	75	4	50
	4.....	.....	.....	.....	.....	.....	.....	1	13	.....	.....
	5.....	.....	.....	.....	.....	.....	.....	.....	.....	1	13

The contrast between the two groups of adults is similar in the main to that found between the groups of children. The good writers do not, as a rule, turn the hand over to the right more than 45° , and they support the hand on the fingers rather than rest it on the side. There is not so much contrast in the angle of the arm to the line of writing, but the good writers do not shift the elbow to the left of the perpendicular, as do some of the poor ones. One of the good writers who held his elbow to the right of the perpendicular may be said to constitute an exception, since he wrote with unusual care and shifted his whole arm at frequent intervals during the writing of a line. This was not found to be generally characteristic of rapid adult writing. The difference which exists

in the angle of the penholder with the arm correlates with the difference in pronation. Three of the poor writers point the penholder from 30° to 60° to the right of the arm. This was due to turning the hand far over to the right. The one good writer who held the penholder more than 60° to the right raised it far up toward a position perpendicular to the paper, and, in spite of turning the hand over about 45° , kept the hand moving freely along the line.

SUMMARY

It is significant that the features of hand position which are most clearly indicated to be favorable to good writing—the support of the hand upon the fingers, a position of the forearm perpendicular to the line of writing, and, to a less degree, an amount of pronation such that the wrist is not tilted more than 45° from the horizontal—are intimately connected with one of the major handwriting movements, namely, the movement of the hand from left to right across the page. Upward and downward movements of the pen can be made easily enough with the hand resting on the side, but this position impedes movement across the page from left to right. The impeding of this movement either causes the hand to be cramped after one or two letters have been written or makes it necessary to interrupt the letter formation to lift the hand or to slide it along. The hand cannot readily slide along while the letters are being formed because it is too firmly planted.

When we come to the description of the training course we shall see that the method there employed applies these principles. No pains are spared to insure that the child shall hold his hand so that it can slide easily on the third and fourth fingers, preferably on the nails. To this requirement is added one of lightness of grasp. This characteristic seemed from observation to belong particularly to the good writers. Furthermore, it is necessary to secure the relation between the position of the arm and of the paper which is indicated by our study to be the best. When the writer faces the desk and bends his arm so that his hand is directly in front of him, his forearm makes an angle of about 60° with the edge of the desk. In order that the forearm shall be at right angles to the line of writing it is necessary to place the paper so that the bottom edge is at an angle of about 30° to the edge of the desk. The plainest way to state this requirement is to say that the line of writing should be approximately parallel to the diagonal from the lower left corner to the upper right corner of the desk.

In order to insure that the pupil shall keep this position of the arm, and that the arm shall be able to move freely, the body must face the desk and must be kept erect, so that its weight does not rest on the writing arm. The weight of the arm rests upon the right forearm, but the weight of the body should not. A little more weight may rest upon the left arm, since it steadies the body, but the right arm should be kept free.

In order to develop further this sideward phase of the writing movement and to make the pupil aware of the position he should take to make it possible, exercises in the side-to-side movement were given. These are the only strictly movement exercises that were included in the course. They will be described in the account of the manual of directions for the course.

THE COMPOSITION OF THE WRITING MOVEMENT

The most detailed study of the composition of the writing movement was made in the intensive laboratory study. Some of the chief matters concerning it were also studied by Mr. Nutt with a larger number of children. The results of his study support the conclusions drawn from the laboratory study and will be presented after the results of the intensive study.

The method which was used in studying the composition of the writing was in substance the same as that employed in studying the hand position. At first the films were run through the projection apparatus and inspected as one looks at an ordinary moving picture. But in this case the film was run slowly or rapidly at the will of the observer, or it was run back in order to repeat a section which he wished to study further. This inspection enabled the observer to get a general idea of the types of movement of the various writers, but it gave no means of making measurements or of demonstrating the results of the observations in a report. Accordingly, certain pairs of photographs were selected which when compared brought out clearly the kind of movement which took place in the interval between them. These pairs represented the position of the hand and arm at the top and bottom of letters, at the beginning and end of words, and at the beginning and end of lines.

Before passing to the detailed study of these selected aspects of movement, a feature of the writing movement of most of the writers which cannot well be brought out by a study of its cross-sections, but which is very evident in the motion picture itself, is worthy of emphasis. Whenever we attempt to describe the writing movement either for purposes of scientific presentation or to lay down rules of conduct we are forced to pick out certain elements of the movement and isolate them from the complete movement. In doing this we are bound to fail to do justice to the variety and flexibility of the actual movement as it can be observed directly, or especially by means of the motion picture. There is too much disposition to think of the movement as made either with the fingers alone while the hand, wrist, and arm remain quiet, or with the arm alone while the rest of the hand, including the fingers, is as immovable as if it were cast in iron. Nothing could be further from the truth. The hand is a remarkably flexible member and is capable of adjustments and changes in shape and position which are so various and numerous in their combinations that it is hopeless to try to catalogue and describe them completely. Detailed descriptions are not necessary. What is necessary is that along with the more prominent elements of the movement we should recognize these minor supplementary elements and admit them into good standing as fellow-servants with their better-known companions.

As in the study of hand positions, each kind of movement was classified in the present study. There were thus distinguished several methods by which the hand is carried along within words and between words, and several movements which are used in forming the letters. These classes are indicated in Table IV.

The frequency of the different kinds of movements which are represented in Table IV is shown in Table V. This table is to be interpreted in the same manner as the table which represents the different kinds of hand position. Of the poor writers eight made the movement within words by an adjustment within the hand, ten made this movement by a sideward adjustment of the wrist, eleven by a backward wrist movement, eleven by turning the hand over to the right, and nine by a sideward movement of the forearm.

A. *The movement within words.*—In the case of movement within words several distinctions between the good and the poor writers may be observed. The adjustment within the hand, Class 1, is made infrequently in some of the groups of good writers and not at all in others. It is more common, however, among poor writers. This is the case both in the University Elementary School and in the Ray School. It is not found, however, in the case of adults.

TABLE IV

BASIS OF CLASSIFICATION OF INDIVIDUALS ACCORDING TO THEIR WRITING MOVEMENT

A. Side-to-side movement within words	$\left\{ \begin{array}{l} 1. \text{ Adjustment within the hand} \\ 2. \text{ Sideward wrist movement} \\ 3. \text{ Backward wrist movement} \\ 4. \text{ Turning hand over to the right} \\ 5. \text{ Sideward movement of the forearm} \\ 6. \text{ Turning hand over to the left} \end{array} \right.$
B. Side-to-side movement between words or word groups	$\left\{ \begin{array}{l} 1. \text{ Sideward movement of the forearm pivoted at the elbow or muscle-pad} \\ 2. \text{ Turning hand over to right} \\ 3. \text{ Lifting arm and shifting} \\ 4. \text{ Wrist movement} \end{array} \right.$
C. Movement on letter strokes	$\left\{ \begin{array}{l} 1. \text{ Movement of the whole arm} \\ 2. \text{ Movement of the hand at wrist joint} \\ 3. \text{ Movement of fingers mostly at third joints} \\ 4. \text{ Movement of fingers mostly at second joints (ordinary finger movement)} \end{array} \right.$
D. Ease of movement along the line	$\left\{ \begin{array}{l} 1. \text{ Easy} \\ 2. \text{ Moderately easy} \\ 3. \text{ Difficult} \end{array} \right.$

They have evidently been subject to sufficient training to eliminate this kind of adjustment. An adjustment within the hand during the writing of a word means almost inevitably cramping the hand toward the end of the word. It means that the fingers are drawn inward usually, so that the hand is more compact at the end of the word than at the beginning. Of the other classes of sideward movement, the clearest case can be made out for the side-to-side movement of the forearm, Class 5. This is uniformly more frequent in the good writers than in the poor writers, and in the case of some of the groups the difference is marked. Of the other

TABLE V

COMPARISON OF THE FREQUENCY OF VARIOUS KINDS OF MOVEMENT AMONG SEVERAL GROUPS OF CHILDREN AND ADULTS

GROUP	CLASSES OF MOVE- MENT	SIDE-TO-SIDE MOVEMENT WITHIN WORDS		SIDE-TO-SIDE MOVEMENT BETWEEN WORDS		MOVEMENT ON LETTER STROKES		LAST OF MOVE- MENT ALONG LINE	
		A		B		C		D	
		No.	Per- centage	No.	Per- centage	No.	Per- centage	No.	Per- centage
Univ. Elem. School: Poor writers (entire group)	1....	8	16	11	30	6	14	1	5
	2....	10	20	7	19	16	36	12	55
	3....	11	22	10	51	4	0	0	41
	4....	11	22			18	41		
	5....	0	18						
Univ. Elem. School: Poor writers who took training	1....	6	10	6	27	3	10		
	2....	5	16	3	14	12	40	8	57
	3....	0	20	13	50	2	7	6	43
	4....	6	19			13	43		
	5....	5	16						
Univ. Elem. School: Good writers	1....	2	10	0	38	3	13	5	42
	2....	5	24	5	21	9	30	6	50
	3....	0	20	0	38	3	13	1	8
	4....	2	10	1	4	8	35		
	5....	5	24						
	6....	1	5						
Univ. Elem. School: Poor writers after training	1....	1	3	0	41	11	55	6	43
	2....	12	38	1	5	6	30	7	50
	3....	3	9	11	50	1	5	1	7
	4....	2	6	1	5	2	10		
	5....	14	44						
Ray School: Poor writers	1....	4	21	6	50	7	47	3	30
	2....	3	16			1	7	0	60
	3....	5	26	5	42			1	10
	4....	2	11	1	8	7	47		
	5....	5	26						
Ray School: Good writers	1....			6	55	5	28	8	100
	2....	4	25			5	28		
	3....	4	25	5	45				
	4....					8	44		
	5....	8	50						
Adults: Poor writers	1....			3	50	4	24		
	2....	6	67			1	6		
	3....			3	50	4	24		
	4....	2	22			8	47		
	5....	1	11						
Adults: Good writers	1....			5	71	6	38		
	2....	4	44	1	14	2	13		
	3....			1	14	2	13		
	4....	1	11			6	38		
	5....	4	44						

types of movement turning the hand over toward the right is uniformly less frequent among the good writers than among the poor ones, but the difference is not great.

Conclusion.—While the variety of movements by which the hand may be carried along within the word is rather large, and the differences between good and poor writers are in most cases not large, the sideward movement of the forearm and of the wrist are shown to be favorable, while the adjustment within the hand and the turning of the hand over toward the right are unfavorable.

B. *The movement between words.*—The chief distinction which is indicated with clearness in the case of movement between words is that the sideward movement is more favorable to good writing than are the other types of movement, including turning the hand over, or lifting the arm and shifting, or a wrist movement. The difference is not great, but it is large enough to be clear, and it is uniform in the case of each group.

Conclusion.—The sideward movement of the forearm is the best means of moving the hand between words.

C. *The composition of the movement upon the letter strokes.*—We have here an aspect of the movement on which there is almost complete agreement among teachers of penmanship. Arm-movement writing is almost universally regarded as proven beyond a doubt to be the only efficient type of writing. It is a bold person who will stand sponsor among penmanship supervisors, or even among supervisors in general, to any degree of finger-movement writing, so thoroughly has the opinion been accepted that arm-movement writing is the best. This feature of the writing, like all the others, however, must be approached impartially if we are to treat writing from a scientific standpoint.

The first fact to be noticed from an examination of the records is that there is not a sharp division of the writers into two classes, as is commonly implied by the distinction drawn between arm-movement writers and finger writers. The remark made above, that the handwriting movement is a complex one and is made by a flexible adjustment of the different parts of the hand and arm to one another, is applicable here. The hand is not a rigid lever which is capable of only one or two types of movement, but it is made up of

flexible parts which are capable of a very large number of combinations of adjustments. Each writer may almost be said to represent a type of movement of his own which is distinct from that of all others. The classification which is here made, therefore, is not intended to indicate a separation into four entirely distinct kinds of movement, but rather a rough division on the basis of movements which differ in their most prominent characteristics while they merge into one another when they are completely described. A very few writers use the arm almost entirely in forming the letters, although none of those who have been examined exclude the finger movement absolutely. Most writers, however, who use the arm movement predominantly, supplement it by some movement of the hand as a whole, or of the fingers. Furthermore, a great many writers who use finger movement chiefly in forming the letters also use the arm slightly in making the upward and downward strokes as well as in carrying the fingers along from one letter to another. The classes, then, into which the writers have been divided must not be regarded as marking hard-and-fast differences.

We may first compare the various groups of individuals with reference to the percentage who use the arm movement and the ordinary finger movement, Classes 1 and 4. The frequency of arm movement appears to be related more closely to the type of training which has been received than to the excellence of the writing. There is no higher percentage of arm movement among good writers than among poor writers in the University Elementary School, and there is actually a smaller percentage among good writers than among poor writers in the Ray School. The poor writers after training, however, and the public-school group as a whole use the arm movement more commonly than the University Elementary School pupils before training. There is a slight preponderance of arm-movement writing among the good adult writers, but this may be due to the fact that they are all from professional educational circles, and therefore have been drilled more than is usual in this type of writing. The frequency of finger-movement writing is remarkably constant in all of the groups, varying from 35 per cent to 47 per cent. There seems to be no tendency toward a smaller percentage among the good writers, or at least if there is such a

tendency it is small. And furthermore, training seems to affect the frequency of finger-movement writing to a very slight degree. This seems to indicate that a certain amount of finger movement is such a fundamental phase of the writing movement that it is next to impossible to eliminate it.

The two types of movement which seem to be interchangeable are not the finger movement and the hand movement. As has already been shown, the amount of finger movement remains constant. It is possible, however, to substitute for the arm movement a movement of the whole hand, Class 2. This movement is particularly frequent among the University Elementary School pupils and is also rather common among the good writers of the Ray School. It does not appear so frequently among the adults. The variation in the proportion of arm movement and hand movement does not seem to correspond closely to the degree of excellence of the writing. The only suggestion that there is a difference in favor of arm movement is found in the fact that the poor writers after training use a larger amount of arm movement and a smaller amount of hand movement. But this difference is not confirmed by a comparison of the good and poor writers either in the University Elementary School or in the Ray School.

Conclusion.—It may not be correct to conclude from the results which have been presented that arm-movement writing is of no value. In fact the author is inclined to believe that it is helpful in moderation, because it is likely to result in a freer movement along the line, in a somewhat lighter grasp of the pen, and in more fluency of movement. It must be admitted, however, that the evidence before us goes to show that the preponderant emphasis which has been placed on this feature of writing is not justified. We must recognize the variety and flexibility of movements of the hand and also the fundamental functions of the finger movements in forming the letters. If we train the other features of writing which have been indicated to be important, we shall undoubtedly obtain a certain degree of arm movement, as is shown by the fact that the University Elementary School group exhibited a larger amount of arm movement after training than before; but we should in all probability regard the arm movement as a legitimate

by-product rather than the reverse. The customary practice is to center attention on the arm movement and to allow the other desirable features to follow largely as by-products. The evidence seems to point to the conclusion that we should reverse this process, that is, aim primarily at the other characteristics, and attain such amount of arm movement as will come as a by-product without special effort. For further evidence on this matter see the account of the field study presented in Chapter V.

D. *Ease of movement along the line.*—This characteristic is one which cannot be measured and can be observed only in a somewhat vague fashion. The figures, however, are given for what they are worth. They indicate very clearly that ease of movement along the line is a factor in good writing. The good writers in all cases exhibit greater ease in carrying the hand across the line than the poor writers, and the writers who have been trained show decided improvement in this respect after training.

Conclusion.—The ease with which the hand moves along the line is an important factor in the excellence of writing.

SPEED CHANGES IN THE WRITING MOVEMENT

The speed changes are not susceptible to the same kind of definite statistical treatment as are the varieties of hand position or of composition of the movement. Considerable time and effort have been spent to find a mode of statistical treatment that will bring out just the element which is significant. This effort has met with but partial success, and the results which have been deemed worth while will be presented below. For the most part, however, we shall have to rely on the type of analysis which was made in the opening part of the description of the results, Chapter III.

The comparisons which have proven fruitful are presented in Tables VI and VII. The first of these tables represents the amount of time which was spent in pauses within words among the different classes of writers. The measurements upon which this table is based are entirely definite and reliable. The table is to be read as follows: The poorest writers in Grade VII B of the University Elementary School spent 25 per cent of their writing time in pauses at the end of the strokes, and the best writer spent 27 per

cent of his writing time in the pauses. Among the children of Grade VIA the poor writers spent 29 per cent in pauses and the

TABLE VI
PERCENTAGE OF TIME SPENT BY CHILDREN IN PAUSES AT END OF STROKES

Grade		Poorest	Best	Before Training	After Training
Univ. Elem. School	VII B	25	27	.....	.....
	VI A	20	52	.....	.....
	VI B	28	32	.....	.....
	V A	16	30	16	34
	V B	32	38	32	49
	IV A	13	36	13	53
	IV B	40	56	40	43
	III A	37	39	37	53
	III B	49	59	40	62
	II A	53	58	53	60
	II B	53	60	53	58
Average		34	44	37	52
Ray School	VIII A	40	41		
	IV A	32	42		
	Average	36	42		

TABLE VII
AVERAGE PERCENTAGE OF STROKES MADE WITH RHYTHM

Grade		Poorest	Best	Before Training	After Training
Univ. Elem. School	VII B	50	68	.....	.....
	VI A	40	95	.....	.....
	VI B	70	84	.....	.....
	V A	37	68	37	64
	V B	63	67	63	81
	IV A	24	79	24	68
	IV B	70	84	70	81
	III A	46	72	46	76
	III B	68	80	68	68
	II A	66	95	66	72
	II B	73	79	73	89
Average		56	80	57	75
Ray School	VIII A	75	96		
	IV A	71	96		
	Average	73	96		

best writer 52 per cent. Each grade group follows the general rule to be observed in the averages; namely, that the better

writers spend a larger amount of time in the pauses than the poor writers.

It is very clear from Table VI that there is an age difference in the percentage of time spent in the pauses at the end of strokes as well as a difference between good and poor writers. The children in the second and third grades, and perhaps in the early fourth grade, spend a larger percentage of time in the pauses than do the older children. This agrees with Meumann's conclusion that the writing of young children is to be described as a series of more or less separate or distinct strokes.

What is the relation of this fact to the fact that good writers pause longer between strokes than poor ones of the same stage of development? Some degree of separation of the total writing movement into strokes is evidently a means to control of the activity. In the young child, whose control is deficient, that separation is extreme. The tendency to separation may also be reinforced by the young child's imperfect idea of the form of the letters and their connections. As he grows older his control increases under practice, and consequently time is economized by reducing the pauses. But in the case of the poor writer this reduction takes place too rapidly for the degree of control which has been developed. The good writer retains better control by maintaining a somewhat greater separation between strokes, or by retarding somewhat the tendency to make the movement more continuous in speed.

In Table VII the matter has been approached in a somewhat different way. In this case the results presented are based, not on definite measurements, but on a division of the strokes into those which are rhythmical and those which are not. The judgment of the experimenters, therefore, determined to some extent the entries of this table. Since the results accord in general with the results presented in Table VI and with observations made throughout the study, they are of significance. A rhythmical stroke is defined for the purpose of this table as one which is made without a break, and which is separated from the next movement by a pause. The writing movement which is rhythmical in this sense consists in a succession of strokes more or less clearly marked off

from each other. Rhythm, in this sense, does not imply that successive strokes are made in the same length of time. Table VII is to be read in the same way as the preceding one. It appears from the averages and also from all but one of the subgroups that the better writers make the larger percentage of their strokes in rhythm and that the effect of training of the type which was given to the University Elementary School pupils is to increase the percentage of rhythmical strokes. These statistical data support the conclusions reached through an analysis of a good writing coordination which was based upon a study of the speed curves and presented in Chapter III.

SUMMARY

From the comparisons of the data presented in this chapter the following elements are found to be favorable to good writing.

1. With reference to hand position:

Such a degree of pronation that the wrist is not tilted more than 45° .

The support of the hand on the nails or sides of the first joints of the third and fourth fingers.

A position of the forearm approximately at right angles to the line of writing.

A position of the forefinger on the penholder below the thumb.

2. With reference to the composition of the movement:

The sideward movement of the hand by rotation of the whole forearm about the elbow supplemented by the rotation of the hand about the wrist joint.

The formation of the letters by a combined movement of the fingers and arm in which either element may predominate.

3. With reference to the speed organization:

The separation of the movement into units by means of pauses, which occupy a larger percentage of total writing time in good than in poor writers.

CHAPTER V

THE ANALYSIS OF THE WRITING MOVEMENT IN THE FIELD STUDY

METHOD AND ORGANIZATION

Mr. Nutt's study, from which certain results and conclusions will be drawn for comparison with the results of the intensive laboratory study, was so designed as to secure speed records from a large number of children and also records of the relative amount of hand and finger movement. The speed records were secured by the modification of an apparatus described by the author in the Yale Psychological Studies.¹ By means of this apparatus an extended tracing of the writing is taken on a moving strip of paper by means of a typewriter ribbon which travels between this moving strip and a sheet upon which the writing is done. The speed of the moving strip is measured by means of an electric vibrator which traces a broken line on it. Thus the original writing can be compared with the tracing, and by this means the location of the pen point at successive intervals on the original writing can be indicated, as in the case of a moving-picture record. Mr. Nutt confined his examination to the study of the time required to make the successive strokes of the word. Rhythm for him, therefore, simply means the degree to which the successive strokes of the word approach uniformity in time or duration.

The relative amount of hand and finger movement was measured approximately by means of a hand tracer. This device consists of a system of levers in the form of a pantograph. One end is clamped to the back of the hand by means of a band, and the other end carries a pen which traces a movement identical with that made by the hand. If the writing is done wholly by the hand and arm the tracer duplicates the movement of the pen. If the fingers, however, contribute a share to the form of the letters the traced record is less complete in detail than the pen record.

¹ F. N. Freeman, "Preliminary Experiments on Writing Reactions," *Psychological Review*, Monograph Supplements, VIII (1907), 301 ff.

In order to obtain a quantitative determination of the amount of arm movement in the formation of the letters Mr. Nutt constructed a scale. This scale represents five degrees of arm movement, in addition to zero. The grade 0 means that the letters are formed wholly by the movement of the fingers. No. 1 represents

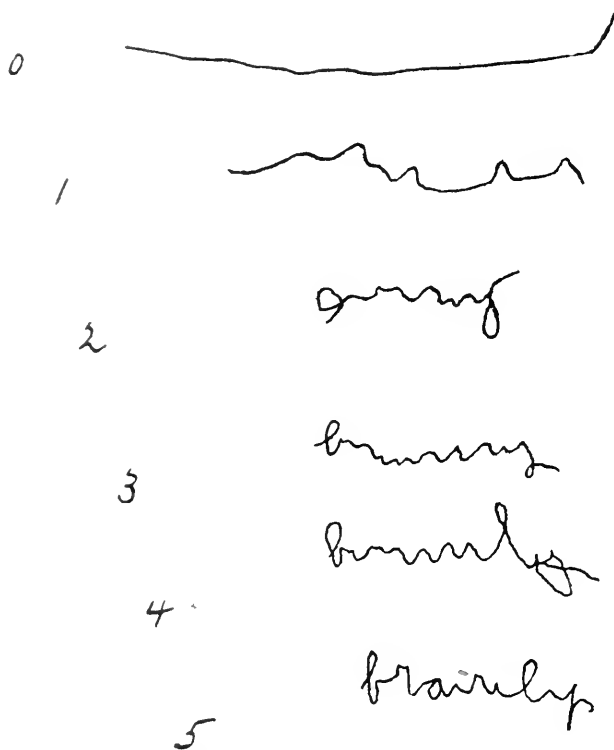


FIG. 44.—Scale for recording the amount of arm movement indicated by the tracer record.

a very small amount of arm movement, which is indicated by slight deviations in the tracer record. Nos. 2, 3, and 4 represent increasing degrees of arm movement, and No. 5 represents that degree at which the word is approximately duplicated by the tracing of the hand. This scale is reproduced in Fig. 44.

The purpose of Mr. Nutt's study was to secure a large enough number of records to make possible some statistical formulation on

a few points. The children from whom the records were to be obtained were selected in such a way as to make possible some comparison of the results of different types of training. Accordingly certain schools were chosen in which the method of teaching emphasized arm-movement training, and others in which the copy-book was used and movement drill was less pronounced. Records were obtained from the five following cities: Kansas City, Kansas;

TABLE VIII
CORRELATION OF RHYTHM WITH AGE

Rhythm	Age							
	7	8	9	10	11	12	13	14
4- 159	14	5	3		1		1	
160- 313	5	3		1	1			
314- 467	8	1	3			1	1	
468- 621	3	3	0	3	4	1		1
622- 775	3	0	3	5	1			2
776- 929	1	2		4	2	1	1	2
930-1,083		4	2	1	2	4		2
1,084-1,237			2	5	2	2	0	
1,238-1,391		3	3	5		2	2	5
1,392-1,545		4	4	4	8		0	0
1,546-1,698			1	3	3	5	1	1
1,699-1,853		1		1	4	0	3	0
1,854-2,007			2		4	3	4	5
2,008-2,161			1		3	2	4	3
2,162-2,315			1			3	1	1
2,316-2,469			1			2	4	1
2,470-2,663							1	2
2,664-2,777								
2,778-2,931						1	1	
2,932-3,085							1	
3,086-3,240								1

Topeka, Kansas; Winfield, Kansas; Mattoon, Illinois; and Grand Rapids, Michigan. At the latter place a larger number of children were studied than in any of the others, amounting to about 150. In all 273 children were studied. These were chosen so as to represent substantially equal numbers from the ages of seven to fourteen, and from Grades II to VIII. The statistical comparisons which have been made from these records deal with the relationship of the composition and rhythm of the writing movement to the quality of the writing, to the age of the pupil, and to the type of training which the pupils received.

THE CORRELATION OF RHYTHM WITH AGE, QUALITY OF WRITING,
AND SPEED OF WRITING

The growing disposition of a writer, as he becomes more mature and more practiced, to make successive strokes in an equal length of time is well brought out in one of the tables from Mr. Nutt's study. The correlation is shown in Table VIII. The numbers at the head of the columns represent the age and the numbers in the left-hand column represent the index of rhythm. This index has been made by combining three different measures, each of which represents the degree of uniformity between the duration of the successive strokes. The first measure represents the number of strokes which are made in the same length of time, the second represents the number of time groups which are necessary in order to include all of the strokes, and the third represents the range of these time groups or the difference between the lowest and the highest. If the successive strokes are made in nearly equal lengths of time the score will be high; if they vary greatly in duration the score will be low. If there is an increase in the degree of uniformity of the time in the strokes of the writing we should expect the scores for the older pupils to be farther toward the bottom of the table than those for the younger ones, and this in fact is what appears.

It has already been hinted that the development of too great uniformity in the duration of the strokes of the word may not be advantageous to the form of the writing. It is easily seen that some of the strokes require more time than others if they are to be properly made, and that too great a disposition to make the strokes in the same length of time leads to a slurring over of the details of some of the letters.

In order to examine this relationship, similar correlation tables have been made out for rhythm and quality. In this case it was necessary to make out a separate table for each age, since if all the ages were lumped together the correlation between rhythm and age, and quality and age, separately, would cause them to appear to be correlated with one another, even though they were not correlated in fact. We may therefore take any age at random and show the correlation table for that age. Tables IX and X show

the correlation tables for age eleven, with the quality worked out on two scales. No evidence of correlation appears in either table.

TABLE IX

CORRELATION OF RHYTHM WITH QUALITY, FREEMAN SCALE

Rhythm	Age Eleven: Quality Grade				
	6-10	11-15	16-20	21-25	26-30
4- 159.....					I
160- 313.....	I				
314- 467.....					
468- 621.....	I		I	2	
622- 775.....			I		
776- 929.....		I		I	
930-1,083.....			2		
1,084-1,237.....				2	
1,238-1,391.....					
1,392-1,545.....	3	2	I	I	I
1,546-1,698.....	I	I		I	
1,699-1,853.....	I	I	I	I	
1,854-2,007.....		2		2	
2,008-2,161.....	I	I		I	

TABLE X

CORRELATION OF RHYTHM WITH QUALITY, AYRES SCALE

Rhythm	Age Eleven: Quality Grade							
	20	30	40	50	60	70	80	90
4- 159.....								I
160- 313.....	I							
314- 467.....								
468- 621.....		I				I	2	
622- 775.....					I			
776- 929.....		I				I		
930-1,083.....			I				I	
1,084-1,237.....				I			I	
1,238-1,391.....								
1,392-1,545.....	2	2	I			3		
1,546-1,698.....	I			I				
1,699-1,853.....		I	2		I		I	
1,854-2,007.....		I				2		I
2,008-2,161.....	I	I			I			

We cannot determine the relationship between the quality of writing and the other types of speed organization from the measurement of simple rhythm which is here represented. There may be, however, certain advantages in rhythmical writing, and these may

be offset by disadvantages. This is not shown by the simple measurement of the duration of strokes. We must rely on the more detailed type of examination of the speed curves themselves. From this we find the characteristics which differentiate the good writer from the poor one.

This matter recalls the other characteristic of mature writing which has already been mentioned and which, when it is developed ahead of the writer's control, is unfavorable in its effect on the form. This characteristic, it will be remembered, is the continuousness of the movement. The writing movement becomes more continuous—the transition from one stroke to another is made with less interruption—and the successive strokes are made more nearly in the same length of time as the writer becomes skilled. But if either process develops too rapidly or too far it is injurious to the writing product.

TABLE XI
CORRELATION OF RHYTHM WITH SPEED

Rhythm	Age Eleven: Speed																	
	42-	40-	38-	36-	34-	32-	30-	28-	26-	24-	22-	20-	18-	16-	14-	12-	10-	8-
	43	41	39	37	35	33	31	29	27	25	23	21	19	17	15	13	11	9
4- 150	I																	
160- 313								I										
314- 407																		
468- 621										2		I			I			
622- 775										I								
776- 929															I	I		
930-1,083															I	I		
1,084-1,237													I		I			
1,238-1,391																		
1,392-1,545													I	5	2	I	I	
1,546-1,698																2		
1,699-1,853										I				I	I	I		
1,854-2,007															3	I		
2,008-2,161															2	I		
2,162-2,315																		

The significance of rhythm, in the sense of uniformity in time in the successive strokes, is further indicated by the fact that it shows a correlation with speed, as revealed in Table XI. It is more marked at some other ages than at age eleven. Uniformity in time is evidently a function of speed more than of form, and it resembles

speed in that an extreme degree of it is probably unfavorable to form.

CORRELATION OF ARM MOVEMENT WITH AGE, QUALITY OF WRITING,
AND SPEED OF WRITING

Further statistics in regard to arm movement may be taken from Mr. Nutt's study. Table XII shows the correlation between the amount of arm movement and age. The numbers at the head of the columns represent the grades in arm movement, according to the scale which has previously been described. Several facts

TABLE XII
CORRELATION OF ARM MOVEMENT WITH AGE

Age	Arm-Movement Grade					
	0	1	2	3	4	5
7.....	10	21	2			1
8.....	10	16	4			
9.....	3	14	5	7	1	
10.....	2	20	4	3	1	2
11.....	6	14	8	2	5	1
12.....		11	12	7	1	2
13.....	1	14	10	6	5	1
14.....	1	16	10	4	4	3

appear in this table which are worthy of comment. In the first place, the amount of arm movement which obtained in any of the systems, even in the later ages, is relatively small. Arm-movement grades 1 and 2 include the large majority of even the fourteen-year-old pupils, in spite of the fact that most of these pupils have been trained in the use of the arm movement directly. The employment of a considerable degree of arm movement, then, may be regarded as a highly skilled art. The same conclusion is to be drawn from the marked correlation which is exhibited between arm movement and age. In ages seven and eight a considerable proportion of the children use no arm movement whatever and practically none use the higher degrees. In the advanced ages, from twelve to fourteen, scarcely any write solely with the fingers and a fair number use the higher degrees of arm movement. These

facts do not give any encouragement to the view that the large majority of children can be trained in exclusive arm-movement writing. They indicate, further, that if we do stress arm movement we should do so from the ages of nine or ten on.

That exclusive arm movement or a considerable degree of arm movement is not of first importance is indicated by the fact that the pupils who make high grades in quality do not use a large amount of arm movement more commonly than do poor writers. We may examine the correlation tables for arm movement and quality for age eleven. Table XIII represents quality as measured

TABLE XIII
CORRELATION OF ARM MOVEMENT WITH QUALITY, FREEMAN SCALE

Quality	Age Eleven					
	0	1	2	3	4	5
0-10.....	2	4	.....	.....	.....	.....
11-15.....	2	3	2	1	.....	.....
16-20.....	.....	1	3	.....	3	.....
21-25.....	2	3	.....	.....	1	1
26-30.....	.....	2	.....	.....	.....	.....

TABLE XIV
CORRELATION OF ARM MOVEMENT WITH QUALITY, AYRES SCALE

Quality	Age Eleven					
	0	1	2	3	4	5
20.....		3	1		1	
30.....	3	2	1	1		
40.....	1	1	2			
50.....	1	1				
60.....		1	2			
70.....	1	2	2		1	1
80.....		1	1	1	2	
90.....	2					

by the Freeman Scale and Table XIV as measured by the Ayres Scale. There is no distinct grouping of the scores along the diagonal from the upper left to the lower right, which would indicate a correlation between arm movement and quality.

We do find, however, some correlation between speed and arm movement, though it is not nearly so close as is commonly maintained by the advocates of this method (see Table XV). All the very slow writers use finger movement. On the other hand, many finger-movement writers write with as high speed as any arm-movement writer. Arm movement appears to prevent slow movement but not to promote unusually high speed.

TABLE XV
CORRELATION OF ARM MOVEMENT WITH SPEED

Arm Movement	Age Eleven: Speed																			
	44- 45	42- 43	40- 41	38- 39	36- 37	34- 35	32- 33	30- 31	28- 29	26- 27	24- 25	22- 23	20- 21	18- 19	16- 17	14- 15	12- 13	10- 11	8- 9	
0.....											1			1	3		1			
1.....		1							1		1			1	2	6	2			
2.....											2		1				2	3	1	
3.....																	1	1		
4.....															1		2	1		
5.....																	1			

SUMMARY

The aspect of speed organization which was measured in this part of the investigation is the relative duration of the successive strokes or units of movement. This is called rhythm.

The duration of successive strokes becomes more uniform as the child grows older and is more uniform in rapid than in slow writing. The uniformity is not greater, however, in writing which is good in form than in writing which is poor in form. Rhythm in this sense, then, is a mark of maturity and facility but not of accuracy.

The amount of arm movement as compared with finger movement is shown by the field study to increase with the age of the child, but it is not more closely related than is finger movement to excellence in form, and is but very slightly more highly correlated with speed. In the absence of correlation between arm movement and form the field study confirms the results of the motion-picture study.

CHAPTER VI

THE PEDAGOGICAL EXPERIMENT

SUMMARY

In the pedagogical experiment a system of exercises was devised to put in practice and test the foregoing principles. In these exercises emphasis was laid first upon hand position. The child was taught to hold his hand so that the wrist did not slant more than 45° from the horizontal, to support his hand upon the third and fourth fingers, to slide it easily upon this support, and to grasp the pen lightly with the fingers curved in a natural manner. Exercises were given to develop free and easy sideward movement of the hand across the page. The organization of the movement into units was encouraged and controlled by requiring the child to write to a count. The count was so arranged as to make the division between the units come at appropriate places in the letters. The speed of the writing was gradually increased as the child acquired practice and maturity. Finally, the general educational principle that the child should have clearly in mind the aim of his practice was applied by directing the child's attention to the analysis of the form of his own letters and to their systematic correction. The detailed manual of directions which was worked out from these principles was applied for a period of from two to three months to a small training class and for a period of eight months to an entire public school. The training class made noticeable improvement, and the public school during the eight months gained nearly four times as much speed as the average yearly gain and between two and three times as much in form.

GENERAL PLAN

The details of this pedagogical experiment were supervised by Miss Mary L. Dougherty, who formulated her procedure and the results of the study in a Master's thesis which is on file in the libraries of the University of Chicago. In the spring of 1916 Miss Dougherty conducted the training class of poor writers of the University Elementary School which has been already referred to. In connection with this training class she took the general prin-

ciples which had been suggested by the results of the laboratory study and developed from them the details of procedure. The directions for this procedure were later elaborated and put into the form of a mimeographed manual. This manual was used during the year 1916-17 as a basis for teaching penmanship in the Longfellow School of Kansas City, Kansas, under the direction of Miss Grace Roberts. The results of that year's work were measured by means of tests and compared with the results in two other schools which used the system in vogue throughout the city. For the further description of the details of the course and the results of the experiment liberal quotations will be made from Miss Dougherty's report.

The organization of the course which is about to be described was based on specific facts and principles which were the outgrowth of the present investigation, and on one general principle which has justified itself in school experience and in pedagogical experiments. In the first place the type of hand position which appears from the comparison of the good and poor writers to be the best was taught the pupils and they were drilled in maintaining it. In the second place emphasis was laid, by means of exercises and directions, on the lateral movement of the hand across the page. In the third place the organization of the movement with reference to speed was developed by means of exercises in writing to a count. An analysis was made of each letter which occurred in the exercises in order to determine what count would be the best basis for the division of the letter into units. The pupil was then trained to write to this count. Writing to count is regarded as an intermediate step in the pupil's development. The pupil first learns to organize his movements in this somewhat artificial way, and later, after he has acquired a fair degree of organization, he is allowed to modify the time given to the successive strokes to suit their individual characteristics. In the fourth place the pupil was taught to analyze the faults of his own writing according to specific categories in order that his efforts might be directed toward improvement in specific directions. To this was added the motivation which comes from definite grading and the pupil's knowledge of his grades.

PRELIMINARY TRIAL COURSE

The course was worked out experimentally, as has been said, with a group of about thirty children ranging from the second to the sixth grades, all of whom had shown in the tests of this experiment that they had especial need of training in handwriting. During the first four weeks all the children had practice for a twenty-minute period five days in the week. At the end of this time a reorganization of the school grades made a change necessary, and the number of periods in a week ranged from two to five, being in every case twenty minutes long. The total number of periods ranged from forty-five in the second grade to twenty-five in the sixth grade, the average being thirty-two periods. Throughout this part of the work careful study of individual children was made and the course was formed to meet the needs that appeared. The first twenty lessons were devoted entirely to the effort to establish the correct position of the hand, pen, paper, and body, to the acquirement of a forward swing in the writing, and to the development of a rhythm which would lead to making with a single impulse each unit-part of a letter. By a unit-part of a letter is meant that part which is allowed a single count, as the oval in *a*, *d*, *g*, or *q*, or the upcurve, turn, and downstroke of the *m* or *n*. For illustrations of the count see Fig. 45. It will be observed that in most cases the count includes as one unit an upward and a downward stroke. This practice agrees with the type of organization of the best adult writers.

The exercises used to develop lateral movement were: (1) a swing on a wide arc both over and under, accompanied by an appropriate rhyme to suggest rhythm of movement; (2) a number of exercises using the simplest one- and two-space letters connected by a long swinging line (see Figs. 45 and 46 for illustrations). These were written to voice count, the class being shown just where the count should come in each letter.

During this time nothing was said about letter form, spacing, or alignment. Slant was referred to incidentally in the discussion of the forward movement, and quality of line was brought to the attention through the insistence on looseness of grasp. The count was usually given on the upstroke, as this seemed

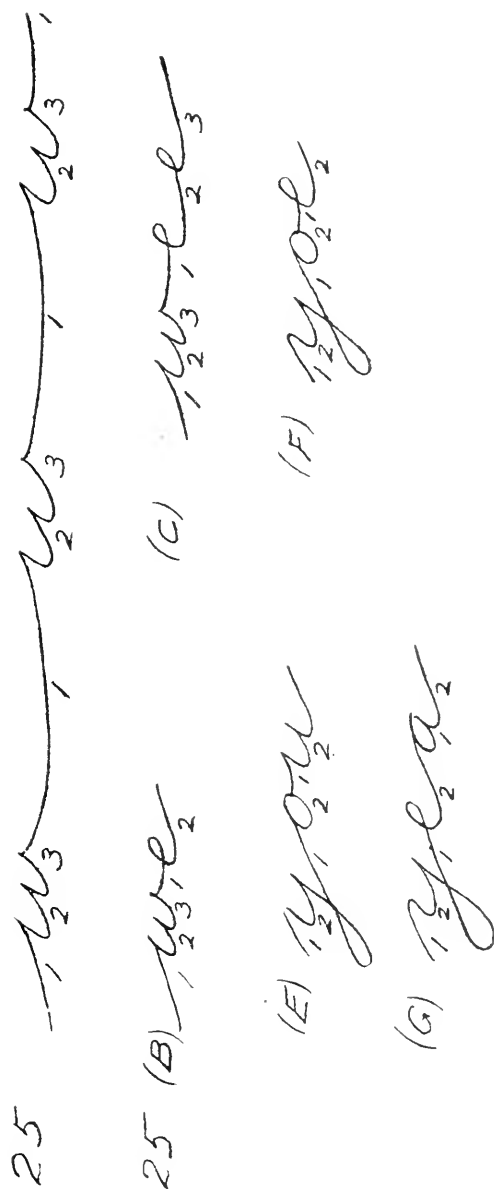


FIG. 45. Illustrations of writing exercises, showing the count

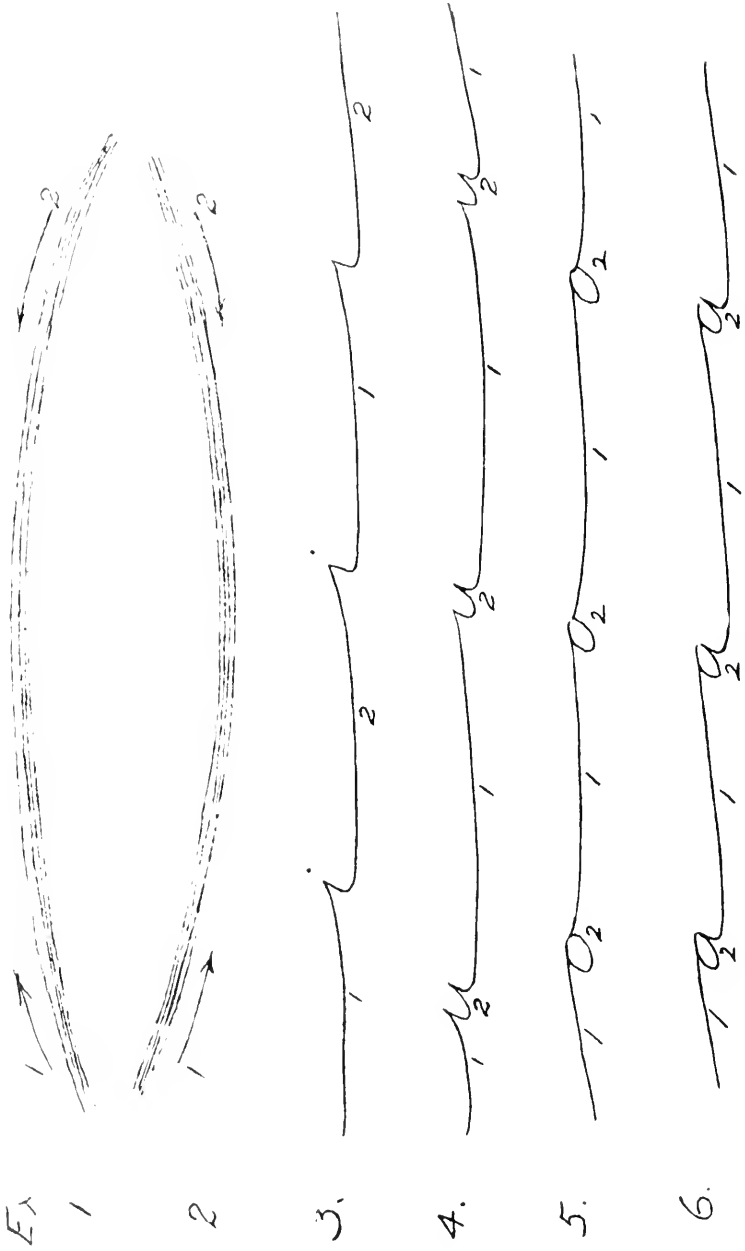


FIG. 46.—Illustrations of writing exercises

to lead more definitely to the freedom of movement wanted than the count on the downstroke, which, because of its direction toward the left of the paper, tended to retard the forward movement. It will be remembered that two of the best adult writers wrote the upward and forward strokes faster than the downward and backward strokes.

At the beginning of the fifth week the metronome was used to mark the time, and emphasis was placed on exactness of time in the writing. The separation between the letters was somewhat lessened and the writing of words began. The words introduced combinations of letters already practiced, and each new letter was introduced in a free-movement exercise before being used in a word. By this means the freedom of movement was fostered while letter combinations were being learned.

At this time the matter of position became an individual instead of a class affair. The teacher held herself responsible for the position of every child, corrected wherever necessary, and attempted to keep the matter at a level of consciousness until the habit was formed by commendation of good position. This helped those who needed correction, as was shown by their evident effort to put themselves in good position when they heard another commended for it. A definite study of individual needs led to suggestions as to changes which would make the writing easier. The fact that there was proper interest in and incentive for work was shown as reports began to come in of spontaneous home practice and of attempts to maintain a good position in writing in other class subjects.

Form was definitely attacked in the writing of words by indicating the desirability of regarding the base line and relative heights of the letters. No suggestion of spacing had been made up to this time except that there should be free movement with plenty of room. While the teacher always wrote the word to count on the blackboard there was no attempt to furnish a *copy* in the usual sense. The aim was to have the children see how it was done rather than what the result was, and the children showed no tendency to make a drawing copy of the work. In the eighth week letter formation was made a point of particular study, with analysis of the letters wherever there was difficulty.

On the basis of the belief that the way to learn to write is to write, there was little discussion and much writing. Exercises for freedom of movement were continued as a part of every lesson. In the sixth week sentence writing was begun.

When the metronome was first used it was set at 112 beats per minute. One unit-part of a letter was made to each beat. The number of beats to a letter was noted and words were given on the blackboard to count and then written by the children. The metronome speed was increased from time to time as the children were able to maintain it. Each increase in speed was first applied to some review exercise and when the class was somewhat accustomed to it a higher speed was used with new exercises. It was found that with every increase of speed it was necessary to give renewed emphasis to position and freedom of movement. In the last two weeks a special effort was made to increase the speed without the loss of good form. For a short time during each period writing on easy exercises was done at forced speed. At the end of the training period the children of Grades II-IV wrote with the metronome at 144 for regular work and at 152 for speed drill. The children in Grades V-VIII used 152 in regular work and 192 for speed drill.

Throughout the course the ideal of criticism was that as far as possible it should be self-criticism based on comparison with one's own work with itself instead of with a set copy. The children were encouraged to find the best of their own work, and with very little suggestion they acquired the habit of discussing their work, presenting reasons why it was good or otherwise. A systematic exhibition of work to encourage criticism was used. Papers were exhibited on which were underscored one or more particularly good forms which had been secured, more or less accidentally. These were examined and discussed by the class and the difference was noted between the parts underscored and the rest of the writing. The beneficial effect of this procedure appeared in the writing which followed.

Results.—The writing of each child was graded by the Freeman chart at the beginning and at the end of the course. Table XVI shows the gain or loss in each category of the chart.

In comparing these figures for interpretation it is necessary to remember that the letter formation receives twice the number of points assigned to the other categories. On this basis the order of gain is: quality of line, 33 points; slant, 31 points; alignment, 27 points; letter formation, 53 points (26); spacing, 21 points.

TABLE XVI
POINTS LOST OR GAINED IN TEN WEEKS' PRACTICE

GRADE	SLANT		ALIGNMENT		QUALITY OF LINE		LETTER FORMATION		SPACING		TOTAL	
	Gain	Loss	Gain	Loss	Gain	Loss	Gain	Loss	Gain	Loss	Gain	Loss
II B.	4	1	2	0	5	0	8	0	4	0	23	1
II A.	4	0	3	0	5	0	7	0	0	0	19	0
III B.	3	0	2	0	2	0	6	0	0	0	13	0
III A.	6	0	7	0	4	0	4	0	4	0	25	0
IV B.	2	0	1	0	3	1	8	0	3	0	17	1
IV A.	4	0	7	0	6	1	8	2	5	2	30	5
V B.	5	0	2	0	4	0	4	0	2	1	17	1
V A.	4	0	3	0	6	0	10	0	6	0	20	0
Total.	32	1	27	0	35	2	55	2	24	3	173	8

At the close of the ten weeks' practice period the test and the photographs showed that some change in the direction aimed at had been made in the writing habits of the children. This seemed to warrant the attempt to test the course still further as to its suitability for the purpose for which it was intended.

ORGANIZATION OF THE EXPANDED COURSE

Because the results of the short course seemed to warrant it this course was expanded to one for eight months' use. A manual of directions was prepared which gives exact instructions in regard to the conduct of the course. Position of body, hand, arm, pen, and paper are first considered. Precision in giving the order to write is emphasized, as definiteness and regularity help in acquiring the habit of rhythm. The size of writing for each grade is prescribed and illustrated by copies which are introduced in the text. In Grades I and II blackboard-work is emphasized as desirable, though it seems unwise to prescribe the extent to which it should be used. As in the short course, an effort is made to have

speed and quality progress together. The following introduction is suggested as a means of motivation.

(A short talk something like this is a good way to begin the course. It should be suited to the class.)

We all want to learn to write well so that when we write letters or stories our friends can read them easily. We can write well and make hard work of it or we can write easily and well. I am going to show you how to write so that it will be easy to write, and then you will be glad to do it. First, we must sit right. Sit straight, hips back in the seat, feet on the floor. (See that all are doing so.) Put the paper in place at an angle of 30° to the desk line. (This will have to be repeatedly illustrated for the beginners.) Put both arms on the desk and let them rest there easily. Make "runners" of your third and fourth fingers. Let them carry your whole hand, sliding back and forth on the paper. (No pencil in hand.) Go clear across the paper. Do it as I count—1, 2; 1, 2; 1, 2; 1, 2. Again, 1, 2; etc. Can you keep with my count? Are you sliding on your "runners"? Is your wrist raised just a little so as to form a bridge? Now again, 1, 2; etc., four times. Take pencil, hold it so. (Show correct position. Be sure that the index finger is on top of pencil, not on left side, and that the thumb is higher on pencil—farther from the point—than the index finger. See that every child's position is correct this time and every time. Place each pencil in a correct position if necessary. It will take less time after a while and less on the whole if correct position is insisted on the first time and every time. Above all things do not get impatient with the child who does not get the position right. They all want to.)

Now can you use your runners with the pencil? Try as I count. Clear across the paper, but do not write yet. Ready. Slide. 1, 2; etc.

Because of the experience in the experimental group the teachers were especially warned against discouragement over some evidence of disorganization of the writing due to focusing the attention for a time on the position, freedom of movement, and time instead of form. Definite directions as to the conduct of each lesson continued through the first month, to a large extent through the third month, and whenever there was difficulty or especial emphasis was needed, throughout the course. The following lessons quoted from the course indicate how definite the instructions were.

LESSON 2

Sit straight, hips back, feet on the floor. Arms on desk. Can you place your paper right? Good. (Do not neglect commendation when possible to give it.) Without pencils use your runners—clear across the paper. Ready.

Slide. 1, 2; etc., four times. Now pencils. Is your position like this? (Be sure that it is.) Now slide, but don't write. Ready. Slide. 1, 2; etc. Look. (On board write Exercise 1 [see Fig. 46], saying verse:

To and fro sway the trees,
Bending in the passing breeze.)

You may write. Ready. Write. "To and fro," etc. Did you keep time? Once more. "To and fro," etc. Now we have made the tree tops. Do you like to swing clear up to the tree tops among the leaves? Look. I am going to swing way up. (See Exercise 2, Fig. 46.) (While making the curve say:

How do you like to go up in a swing,
Up in the air so blue?)

Make the tree tops again. Are your runners ready? Is your pencil right? Are you holding it loosely? (Test a few by pulling it out from the fingers.) Ready. Write. "To and fro," etc. Let's swing up to the tree tops. "How do you like to go up in a swing," etc. Now we will slide another way. I will show you. (See Exercise 3, Fig. 46.) Make long slides so that you can put only three on a line. Try again. See how I count. (Put it on the board with a count.)

LESSON 5

Take a clean sheet of paper. We have been practicing all the week. Today we are going to make all our exercises. Remember that the most important thing is the way we do it. Paper right, feet right, up straight, hand on runners, pencil loose. Without writing, slide on your runners clear across the paper. Ready. Slide. 1, 2; 1, 2; etc. Now hold your pencil right and put your name and grade and the date on the top line. Now, everybody ready. Watch. (Put on the board Exercises 1 and 2, saying rhyme.) You may do this. Be sure you swing clear across the page. Don't let your tree tops come too low. Ready. Write. "How do you like," etc. Make this exercise twice. (Then put on the board Exercise 3 and have them do it to count, and have them do the same with Exercises 4, 5, and 6, Fig. 46.)

The chief aim in organizing the course, aside from attention to position, is the organization with regard to the time element. For this it is necessary to analyze each letter as to the count best suited to it, and in words the count must be adapted to take account of desirable ways of connecting letters. (See Fig. 45 for illustration.) Often it was found that the count assigned to a letter influenced the form of the letter. The easier small letters are introduced first and those requiring the same type of movement are grouped together. The easier capitals are introduced before the more

difficult small letters, and sentences and proper names are given as an incentive to learning how to write the capitals.

The emphasis is on different factors at different stages of the work. In the beginning the attention is focused on position and freedom of movement in a rhythmic manner. The attention is turned somewhat gradually to form. For example, such points as the top of the small *a* and the proper place of crossing and closing the *f* are noticed when the letter is introduced, and the emphasis is laid on these points in the writing which follows. In the fifth month letter formation is emphasized. In this connection an analysis of letters is made as to the points of difficulty. In connection with this study especial emphasis begins to be placed on the self-criticism which has been encouraged from the first. To make this self-criticism more definite and more intelligent, in the sixth month the Chart for the Diagnosis of Faults in Handwriting¹ is given to the teachers with careful instructions as to their own and the pupils' use of the chart. This directed criticism proved valuable in the improvement of form, as was shown in the change between the third and fourth tests, which came before and after it had been inaugurated. During the seventh and eighth months the use of the metronome is gradually eliminated except in speed drills. This is for the purpose of establishing a habit of rhythm in writing apart from an external stimulus. An effort is also made to increase the speed of writing without loss in form. The device for this is a speed game, in which for a short time during a writing period the class writes a familiar exercise at a speed beyond that used in the regular writing. This speed is increased from time to time according to the judgment of the teacher.

In this course nothing at all is said about the type of movement in itself. The emphasis is on freedom and ease in the writing. No peculiar formation of the letters is required. They are to be distinctive enough in form to make them easily recognized, but there is allowance for individuality in the work of the pupils.

The schools which co-operated in the experiment were the Longfellow, the Bryant, and the Quindaro schools of Kansas City, Kansas. The following numbers of pupils were present at the first

¹ Devised by F. N. Freeman and published by Houghton Mifflin Co.

and last tests and are included in the tables: Longfellow, 149; Bryant, 194; Quindaro, 157. The Longfellow School used the course, which was sent to them in detail, and faithfully followed the suggestions given. The other schools were asked to send in test papers at the time that the Longfellow School did, but not to use, consciously, any of the methods prescribed for that school. The co-operation of these schools was as important a part of the experiment as that of the Longfellow School, since the validity of the entire work might well be questioned if no check group were used and reported as a part of the experiment. In the report the Longfellow School will be designated as the training school and the Bryant and Quindaro schools as the check schools.

From the training school and the two check schools concerned a test was given at the close of the first week of school in September. One week was allowed to give opportunity for learning the material to be used and for a return to the habits of work after the vacation. The directions for this test and the others given during the year were those published in an article entitled "Hand-writing Tests for Use in School Surveys,"¹ a reprint of which was sent to each teacher. Other tests were given in all the schools on December 15, February 23, and May 15. After grading the work of the first three tests, suggestions were sent out to the training school as to points which needed attention, and special advice and a rough report of the standing of the different grades were given.

The check schools received no communication during the year except the requests for tests at the proper times. The method used in the check schools was a somewhat loose following of a modified Palmer System. There was no systematic supervision of the work, so it is probable that the work was somewhat individual in character in the different classes.

In the training school the explicit directions and letters of advice took the place to a large extent of the direct supervision, but the building was visited in February and in March by the authors of the course. At these two visits the work was inspected, questions answered, and advice given.

¹ *Elementary School Journal*, XVI (1916), 299.

RESULTS OF THE EXPANDED COURSE

In the following tables and charts the results of the experiment are presented. Further details of the results with discussion may be found in Miss Dougherty's longer report. The progress in speed and quality which was made in the three schools is represented in Table XVII. The scores in quality which are used in this table were obtained by the use of the Freeman Chart for the Diagnosis of Faults in Handwriting. The grading was all done by one person, who had been trained carefully in the use of the scale. In addition to the grading the papers were directly compared, and if any marked discrepancies were found the grading was altered before the results were tabulated. The process was uniform in the three schools. The scores which are given as the standards were obtained by using the results of a study of fifty-six cities.

From the averages at the bottom of the table it appears that the training school made marked gain in both speed and form, while the two check schools gained chiefly in speed. The training school made approximately four times the standard gain in speed and between two and three times the standard gain in form. The check schools made approximately three times the standard gain in speed but only a little over one-quarter the standard gain in form.

The results which are presented in Table XVII may be inspected more conveniently in the charts in Figs. 47 and 48. The lines in Fig. 47 represent the progress in the form of the writing made by individual grades from the first to the last test in the three schools. The lines in Fig. 48 represent the progress in speed from the first to the last test.

It is evident from Fig. 47 that every grade in the training school surpassed the corresponding grades of the other two schools in form, both in the amount of progress from the first to the last test and in the excellence of the final attainment at the end of the year. In most cases the superiority of the training school is very large. Fig. 48 shows that the training school made greater progress in speed than did the other schools. In some grades the progress of the training school was greater than the progress of other schools, and in other grades less.

TABLE XVII

COMPARISON OF AVERAGE PROGRESS OF THE TRAINING SCHOOL AND THE TWO CHILD SCHOOLS

[illegible]

The progress in form and in speed from one grade to another and the change which took place from the first to the fourth test are represented in Fig. 49. The upper figures represent form and the lower ones speed. The left-hand figures represent the condition at the first test and the right-hand figures the condition at the last test.

Consider, first, the form curves. In the first test the form or quality in the training school is, on the average, not greatly differ-

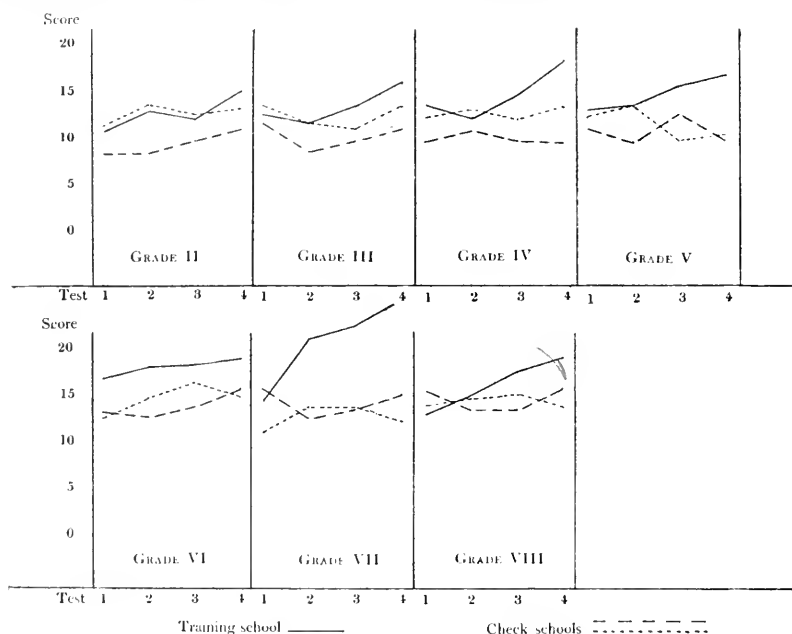


FIG. 47.—Comparison of the progress in form of writing in the training school and the two check schools from the first to the last test.

ent from that of the two check schools. All three schools are below the standard from the fifth grade upward. In the fourth test the check schools have remained in about the same relative position to the standard while the training school has progressed so far as to be entirely above it, except in the eighth grade.

In speed the two check schools were above the standard in most of the grades at the beginning of the year, while the training school was somewhat below. In the fourth test all of the schools,

including the training school, were above the standard in every grade, and the average attainment in all of the schools was substantially the same. It is apparent that the check schools have made great progress in speed but very slight progress in form. The training school, on the other hand, has made great progress in both form and speed.

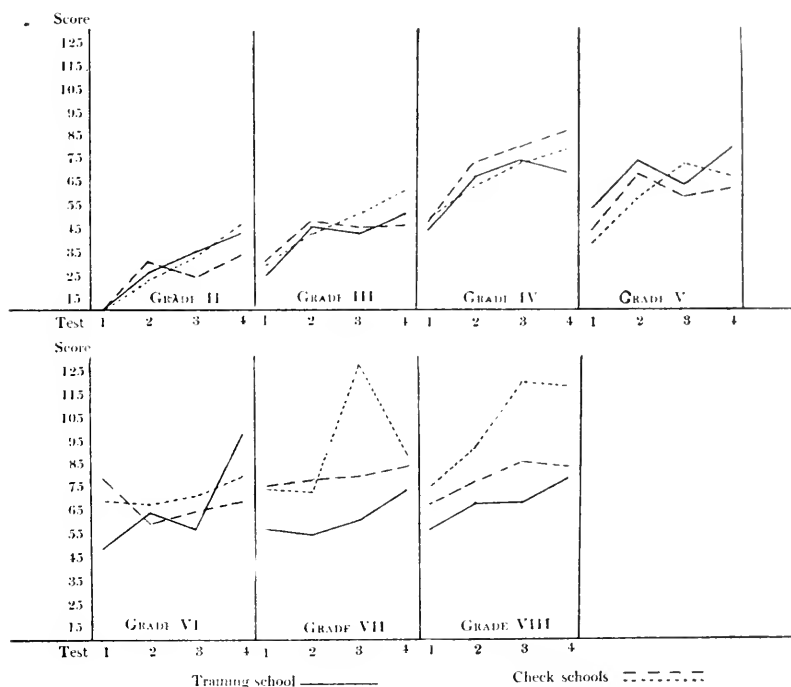


FIG. 48.—Comparison of the progress in speed of writing in the training school and the two check schools from the first to the last test.

In addition to comparing the same grade in different schools, we may compare each grade within a school with the next grade above it. The difference between two successive grades at the beginning of the year may be taken as a measure of the amount of progress which we may expect a grade to make during a year. For example, the fourth grade should have approximately the standing in the last test of the year which the fifth grade had in the first test. If we compare the standing of any particular grade in the last test

with the standing of the next grade above it in the first test, we have a means of determining whether or not the lower grade has made the equivalent of a year's progress. Such a comparison is made for the three schools in Fig. 50. This figure is to be interpreted as follows: In the upper set of figures is shown the standing of the grades of the Longfellow School, and in the two

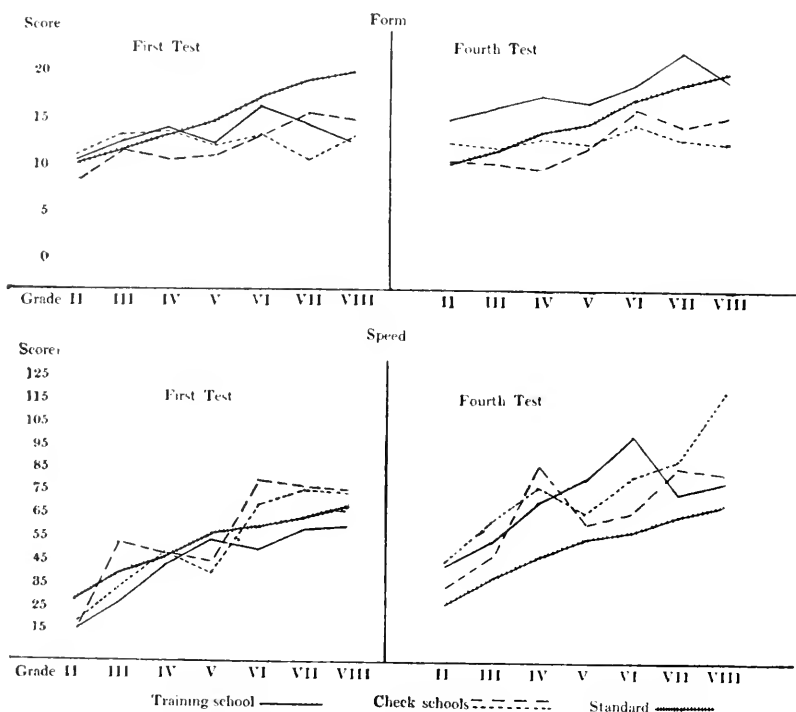


FIG. 49.—Progress through the grades in the training school and the two check schools in comparison with the standard.

lower sets of figures the standing in the other two schools. The pairs of columns on the left present comparisons of the form in the third grade at the beginning of the year with that of the second grade at the end of the year, designated by 3 and 2, respectively. In the next pairs of columns is shown the same comparison for speed. If the column which represents the lower grade is higher than that which represents the next grade above it, there is an indication that the lower grade has made more progress than we

should expect during the year. If the contrary is true, the lower grade has made less than the expected progress.

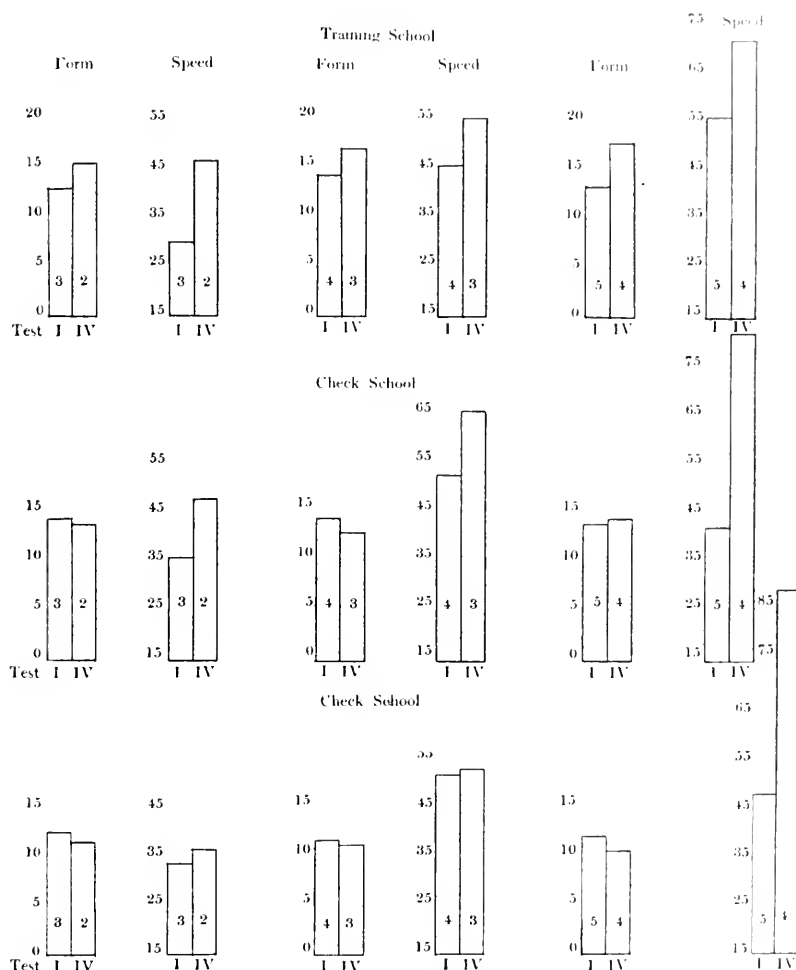


FIG. 50.—Comparison of consecutive grades. The standing of each grade in Test IV compared with the standing of the next grade above it in Test I.

This comparison indicates that every grade in the training school has made more than the expected progress both in form and speed, and in most of the cases the excess is considerable. In

the two check schools only two grades have made more than the expected progress in both form and speed. One has exceeded the

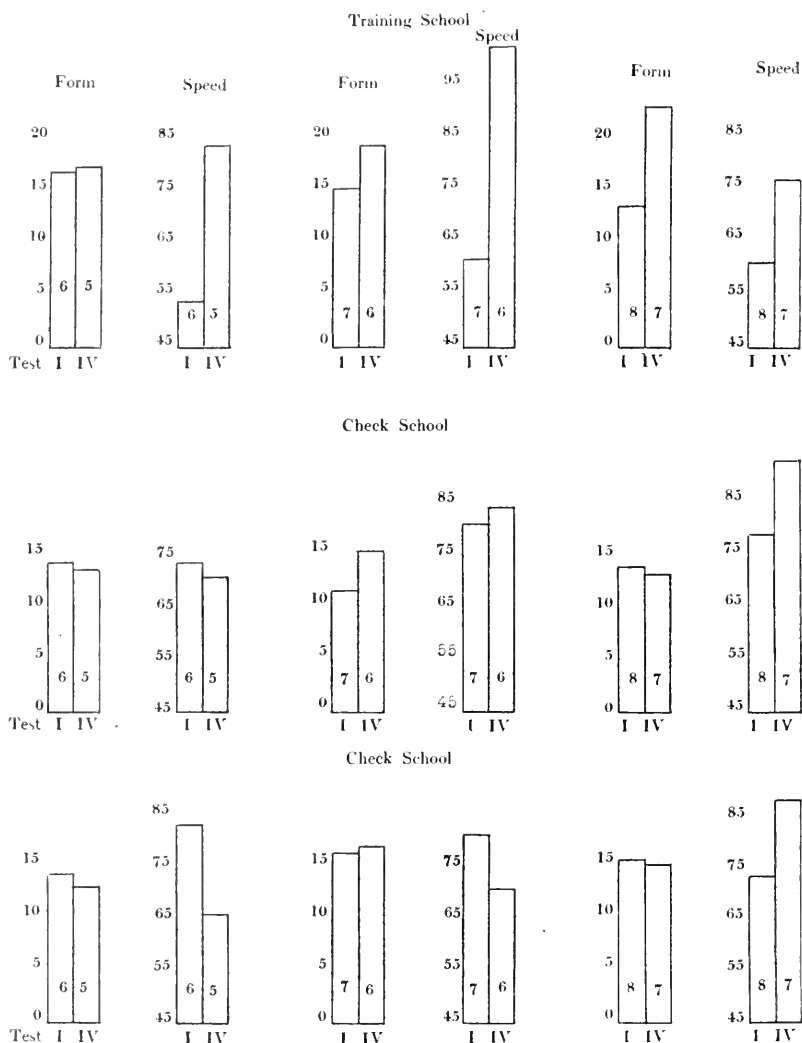


FIG. 50—Continued

expected progress in form alone and seven in speed alone. The remaining two have made less than the expected progress in both form and speed. The training school makes a very excellent

showing on the basis of this internal comparison, indicating that unusual progress was made during the year, while the progress in the check schools was about the same as usual.

These statistical results may be supplemented by the presentation of a few individual cases in concrete form. In order that the selection of these cases might not seem to show bias and favor the results of the work, they were chosen on the basis of their recorded scores rather than from an examination of the specimens themselves. The scores of all the papers were inspected in order to discover cases in which the same amount of progress was made from the first to the last test as was made on the average in their respective grades. Thus the progress which is shown in these papers represents very closely the average progress which has been made by the grade as a whole. The specimens are reproduced in Fig. 51. In each case the specimen includes all that the child wrote in two minutes, so that the speed of writing may be judged as well as the form.

The two specimens of handwriting by a second-grade child must be judged in connection with the fact that the writing at the end of the year is considerably smaller, which makes it more difficult, and that the child wrote between five and six times as much within the same period at the end as at the beginning. The third-grade child wrote with pencil at the beginning of the year and with pen at the end, and in addition wrote two and a half times as much in the last test as in the first test. The last test shows a very encouraging fluency and a very fair amount of control for a third-grade child. The fourth-grade child shows very good gain in speed, in the form of the letters, and in the fluency of the movement. The fifth-grade child has gained very largely in form and shows a decided gain in the control and smoothness of the movement. The sixth-grade child has more than doubled her speed and has gained in smoothness and regularity of writing. The writing at the end of the year is somewhat too crowded and the slant is extreme; if but these faults were corrected it would be very good indeed. There is a little excess movement shown in the case of the seventh-grade pupil, but this is a fault which can be overcome and is much less serious than the cramped movement with which

Mix a pan cake

September

Mix a pan cake
 Stir a pan cake
 Pop it in a pan
 Fry a pan cake
 Goss a pan cake
 Catch it if you can

May

FIG. 51.—The writing of a pupil from each grade (II-VIII) at the beginning and end of the training course. The pupils were chosen to represent the average gain of the grades.

GRADE III

The rain is raining all around,
It falls on field and tree,
It rains on

September

The rain is raining all around
It falls on leaves and tree
It rains on the umbrellas
A-ho on the ship at sea
The rain is raining all around
It falls on fields and trees.

May

FIG. 51 (Continued)

GRADE IV

The rain is raining all around,
It falls on ships and

It rain is raining all around,
It falls on field and trees,
It rains on unroofed castles,
and on the ships at sea.

10

The

September

FIG. 51 (Continued)

The rain is raining all
around,
It falls on field and trees,
It rains on the umbrellas
here,
And on the ships at sea.

The rain is raining all
around,
It falls on fields and trees,

May

FIG. 51 (Continued)

GRADE V

Breathes there the man with soul
so dead
Who never to himself hath
said.
This is my own my native
land.
Whose heart hath never with-
him deem'd.
As

September

FIG. 51 (Continued)

GRADE V

Brethes There the man with soul so
Dead
Who never to himself hath said
This is my own my native land
Whose heart hath never within him
burned
As home his footsteps he hath turned
From wandering

May

FIG. 51 (Continued)

GRADE VI

Lives there a man with soul so dead,
Who never to himself hath said, this
is my own my native land!
Whose heart hath never within

September

FIG. 51 (Continued)

Loves there a man with soul so dead,
Whom never to himself he said
This is my own, my native land,
Whose heart hath never within him turned
As home his footsteps he hath turned
From wandering in a foreign land!

Lives there a man with soul so dead,
Who never to himself hath said
This is my own, my native land

May

FIG. 51 (Continued)

GRADE VII

Breathes there a man with soul so
dear,
Who never to himself hath said,
This is my own

September

Breathes there the man with
soul so dead,
Who never to himself hath
said.

This is my own my
native land.
Whose heart hath never
wrought him him burned
As homeward¹²⁵

May

GRADE VIII

Breathes there the man with soul so dead,
Who never to himself hath said,
This is my own, my native land!
Whose heart hath ne'er within him burned,
As home his footsteps he hath turned
From wandering on a foreign shore

September

GRADE VIII

Breaths there a man with a soul so dead
Who never to himself hath said
This is my own, my native land,
Whose heart hath near within him burned
As home his footsteps he hath turned
From wondering on a foreign strand

May

FIG. 51 (Continued)

the first specimen was evidently written. The speed is about doubled. A gain in control is also shown by the eighth-grade pupil.

These favorable statistical results are confirmed by the interest and approval of the teachers and the principal of the school where the course was given trial. The experimental work of the laboratory has evidently discovered a principle which is not only scientifically true, but which can be made to work in practice to the advantage of the teaching of penmanship.

CHAPTER VII

PRACTICAL RECOMMENDATIONS

We are primarily concerned in this study of the efficiency of penmanship with handwriting as a movement. This preoccupation with the movement phase assumes that the difficulty which confronts the child in learning to write well is concerned more with the movement than with the perception of the letters. This is not to be taken to mean that defects in writing are never due to faulty perception. The penmanship course which has been outlined in the preceding chapter includes a systematic examination of the form of the writing by the child made according to specific categories. It seems necessary to direct the child's attention in a systematic way to the analysis of the form of the letters. What this assumption does mean, on the other hand, is that characteristically poor writers meet their chief difficulty, not in form recognition or perception, but in the control of the movement. It is seldom that a child with some attention directed to form cannot be led to see his errors. It is a very difficult matter for some children to correct the defects which they are able to recognize.

We may, for convenience, distinguish between that part of the writing movement which has to do with letter formation and with the movement from one letter to another, which includes the maintenance of a proper relationship between the successive letters in size, slant, and spacing. To make a succession of letters and words with smoothness and uniformity requires additional elements of movement to those which are involved in the production of separate letters. We may consider first the conditions of this more general phase of the movement by which a succession of letters is produced.

In order that this larger element in the writing movement may be carried on smoothly and accurately the position of the hand and arm must be such that the hand can slide easily along the line while

the letters are being produced. This condition can most readily be met when the hand rests upon the third and fourth fingers, and not upon the side. In order that the hand shall not be in danger of resting upon the side, the wrist should not be tilted more than 45° from the horizontal. A level wrist does not seem to be necessary, but it is better to train the child to hold his wrist nearly level in order to avert the extreme side position.

The manner in which the hand is carried along the line is also affected by the position of the arm in relation to the paper. The most efficient writers move the hand along the line by a sideward movement of the whole forearm, supplemented in lesser degree by sideward movement of the wrist. If this is to be accomplished without changing the position of the hand or shifting the arm, the forearm must be nearly perpendicular to the line of the writing. When the elbow is placed considerably toward the right, as is often the case, the arm must be drawn back or the hand cramped as the pen proceeds from one letter or word to another.

When the conditions which allow a smooth and easy sideward movement of the hand have been met, it is desirable to train the child directly in this movement by giving him special exercises. These exercises may consist in making slightly curved lines which require a wide sweep of the pen across the page, or in making letters at wide distances apart, joined by connecting lines.

The manner in which the penholder is grasped is of importance for the production of the letters. This is true whether the letters are to be produced by a movement largely of the fingers or by a movement of the arm. The requirements of holding the pen may be summarized in the one statement that the grasp should be reasonably loose and natural; that is, the fingers should be in their natural position. Tightness of grasp and unnaturalness of position usually go together. When the grasp of the penholder is tight, the muscles by which the movement is produced are already in a state of tension and cannot move freely and easily. When the fingers are drawn upward and there is a sharp angle at the middle joint the grasp of the penholder is usually tight. A specific point upon which the statistics are quite clear concerns the relative position of the index finger and the thumb on the penholder. The index

finger should rest against the penholder below the thumb. It is obvious that this is the natural position, since the finger is longer than the thumb; and when it is violated there is almost bound to be a cramping of the fingers.

Within such gross limits as these wide variations may be allowed both in position and movement. The differences in the formation of the hand or in the type of nervous activity of different individuals make it desirable to permit considerable individuality. A study of the handwriting movement impresses one with the tremendous variety of ways in which the elements of the movement may be combined. To attempt to cast every individual into the same mold is to restrict this natural variability. There are certain limits beyond which individual variation should be curbed, because it results in a deterioration of the writing product. These limits have been indicated in the report.

Intermediate between those elements of position which have been described and the subtler phases of movement which cannot be discovered by ordinary observation are the grosser aspects of movement which are ordinarily referred to when we speak of the handwriting movement. It is these elements which have been included in the present study under the term "composition of the movement." The writing movement may be composed in varying proportions of the movement of the fingers, the movement of the hand as a whole, and the movement of the arm. Within the general class of finger movement or of hand movement there are also numerous minor variations.

The results of the study do not support the exclusive arm-movement theory which is prevalent among the authors of present-day writing systems. In the first place, there is scarcely a writer, so far as this investigation indicates, who uses solely the arm movement in the production of the letters. When we confine our examination to elementary-school pupils, with whom alone we are concerned in public-school teaching, we find a relatively small per cent in any system or any grade who use the arm movement chiefly. The fingers always co-operate to a greater or less extent, and usually to a greater extent, in the formation of the letters. Efforts to develop an exclusive arm movement are not successful.

In the second place, there is not that closeness of relationship between the degree of arm movement which is used and the excellency of the writing which is implied in the extreme emphasis which is put on this type of movement. Good writers use the finger movement as frequently as do poor writers. The chief difference between the good and the poor writers appears to be that poor writers use the other varieties of movement, such as the hand and the wrist movements, with greater frequency than do the good writers. The indications are that the fingers and the arm should be the chief components of the writing movement.

While training in arm movement is beside the point in its aim, it does have indirect consequences which are of value. The comparison between the public-school children who had been trained in arm movement and the University Elementary School children indicates that the former had developed a better organization of the movement from the point of view of speed. We shall defer the detailed consideration of this for a moment, but here simply comment upon the fact that the writing drill which has as its primary, avowed aim the development of the arm movement does, as a secondary consequence, develop a type of speed organization which is valuable. The contention of this report is that it would be more economical to aim directly at the proper type of speed organization, and not to attempt the well-nigh impossible task of developing exclusive arm movement in all children.

The fact that the training class in the University Elementary School developed a fair amount of arm movement supports these conclusions. It indicates that a moderate amount of arm movement is useful. It indicates, further, that for the development of the degree of arm movement which is desirable no direct specific drill, in which the child's attention is called to arm movement, is necessary. The degree of arm movement which is desirable will come as a by-product of the adoption of a favorable position and of drill in fluent lateral movement and in rhythmic writing.

The most important conditions of efficiency, as determined by this study, are those which relate to the speed changes in the writing movement. The writing movement is produced by a series of muscular contractions, which are in turn caused by a series of

nervous excitations. The speed changes in the movement of the pen point are the expression of the mode of timing and the degree of vigor or force of these nervous excitations. When a long stroke is made with greater speed than a short stroke, this is an indication that the force of the nervous impulse is appropriately related to the time element of the movement. It is an expression of the tendency toward uniformity in the duration of the successive strokes which is characteristic of regular and rhythmical movement. When, on the other hand, a short stroke is made with as great or greater rapidity than a longer stroke irregularity is shown. When similar strokes are made with widely varying speeds there is an indication of irregularity in the succession of the nervous impulses.

Not only must the successive nervous impulses have the characteristic of regularity, but the impulses must also be adapted to the forms which are to be produced. This adaptation is brought about by good writers by dividing into units the total movement by which a word is written. These units are made to correspond to the characteristics of the form of the letters. There are certain turning-points in form which are appropriate as division-points in the movement. They may be described as resting-places in the flight of the pen. The strokes between these resting-places are made as units, and this organization of the movement seems to be favorable to smooth lines and well-formed letters.

Writing to a count or to time is a device which favors the development of the speed organization of the writing movement which has just been described. The counting must be adapted in its average speed to the level of the ability of the pupil. It must also be adapted to the forms of the letters which are to be produced. This means that those strokes which are the natural units of the writing movement must be isolated and designated by the count. If the total amount which is included within a count is too great or too small the speed of the movement on this count will be disproportionate.

When a progressive course is organized which puts into practice the principles in regard to position and movement which have been outlined, the results indicate that the conclusions are, on the

whole, correct. The pupils who were taught by the application of these principles made 37 per cent greater progress in speed and ten times as much progress in form as the pupils in two other schools which were compared with the experimental school, and they made more progress than is usually made in a year in the experimental school itself. The course itself is undoubtedly capable of many improvements, but its general success is confirmatory evidence of the correctness of its fundamental principles.

SUMMARY

1. The forearm should be nearly perpendicular to the line of writing.
2. The hand should face downward, so that the wrist is not inclined more than 45° .
3. The hand should slide on the third and fourth fingers.
4. The grasp of the pen should be light, with the fingers moderately curved and with the forefinger resting on the penholder lower down than the thumb.
5. The sideward movement of the hand across the line should be free and exercises should be given to make it so.
6. The letters may be formed by such a combination of finger and arm movement as is most natural to the pupils.
7. The pupil should be given training which will form the habit of organizing the writing movement into units which are well adapted to the forms of the letters. While this habit is being formed counting is a helpful device.
8. While it did not grow directly out of the analytic experiment, one further feature of the method amply justified itself in the pedagogical experiment. The pupil should be taught to make systematic criticism of his own writing and should have definite knowledge of his standing and progress.

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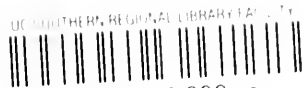
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